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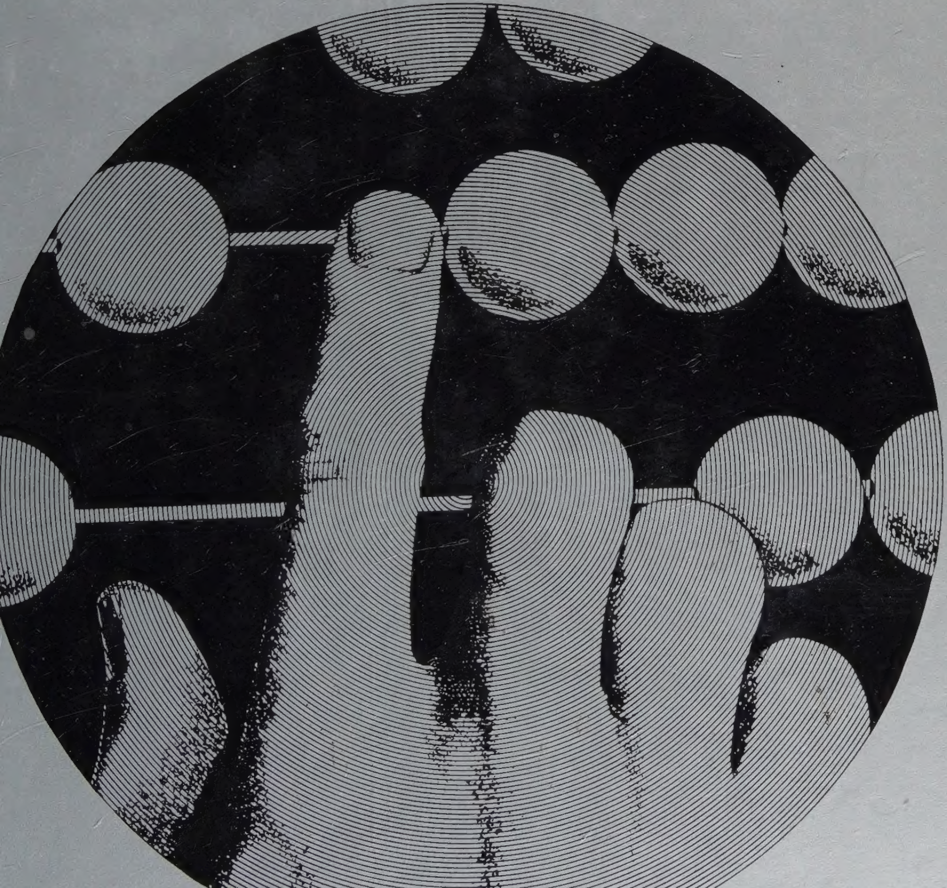

Computers and the manager

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COMPUTERS AND THE MANAGER

ECONOMIC EVALUATION OF COMPUTER BASED SYSTEMS

Book 2

Workshop Report

edited by

C. W. BLAXTER & W. E. M. MORRIS

The National Computing Centre Limited is a non-profit organisation supported by industry, commerce and government. It is dedicated to promoting the wider and more effective use of computers throughout the economy. In realising its objectives the Centre

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provides *education* and *training*

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co-operates with, and *co-ordinates* the work of, other organisations concerned with computers and their use.

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Foreword

By the middle of 1968, the NCC had received many requests from its members for some action in the Economic Evaluation field. Accordingly an NCC project was established with an interdisciplinary group organised into two committes—the Project Co-ordinating Committee and the Executive Committee. Both committees are made up of representatives from users, Universities and NCC staff. The group is sponsored and partly financed by the National Computing Centre. Three areas of activity were established as, follows:—

—a literature search.

—a U.K. current-practise survey.

—a pilot investigation into one application area.

The Current Practice Survey was conducted in conjunction with the British Computer Society and the British Institute of Management, since these bodies had a similar activity in mind at the time in question.

The application area chosen was Inventory Management and a Working Party was set up to pursue a pilot study. A report was produced in the latter part of 1969, and made available as a project research document for loan by interested parties.

The Report included recommendations for further work with regard to the project as a whole, and a workshop was proposed for a body of approximately 50 invited people as a means of

—reviewing the work to-date and soliciting ideas for 'on-going' activity.

—hearing the formal views of relevant experts with an international reputation.

—providing a forum for wide informal discussion.

—guiding the next phases of project work.

The workshop proposal was accepted and a date of January 1970 agreed. The Inventory Management Report was regarded as an important input, and plans were made for circulating it to all participants prior to the event ("Workshop Report" is published in Book 2).

The aim of the Economic Evaluation of Computer Based Systems project is to improve the ability of management to evaluate the costs and benefits stemming from the use of computers in information and control systems. In doing this the project helps necessarily to improve the management of the process of change to information and control systems involving computers.

The disciplines represented on the Executive Committee are accountancy, computer science, mathematics, operational research and sociology. The principle purpose of the group is to present a coherent stategy for the cost-benefit analysis required in the appraisal and monitoring stages of a project and to provide improved methods for quantifying costs and benefits. An important aspect of the work has been therefore concerned with the development of new implementation methods to deal with currently neglected problems, especially those involving human factors.

The members of the two committees and their companies/organisations at that time are—

Project Co-ordinating Committee

T. A. Duerden	(British Aircraft Corporation) *Chairman*
C. W. Blaxter	(National Computing Centre)
R. Boot	(National Computing Centre)
G. S. Dorey	(The Pfizer Group)
J. Hawgood	(University of Durham)
F. F. Land	(London School of Economics)
A. Mercer	(University of Lancaster)
Enid Mumford	(Manchester Business School)
C. M. Reddington	(Liverpool Corporation)
G. I. Ryder	(English China Clays Ltd.)

Executive Committee

F. F. Land	(London School of Economics) *Chairman*
R. Boot	(National Computing Centre)
O. B. Chedzoy	(Bath University of Technology), *until June 1970*
A. Hall	(Brunel University), *Student Research Assistant, until January 1970*
J. Hawgood	(University of Durham)
Enid Mumford	(Manchester Business School)
C. M. Reddington	(Liverpool Corporation)
W. E. M. Morris	(University of Durham), *Secretary and Project Officer*

The reports of the project published so far have been prepared in three volumes which comprise—

Book 1 —"Working Party Report" edited by W. E. M. Morris. This book also contains an Appendix—"Decision Strategy" by J. Hawgood and E. Mumford.

Book 2 —"Workshop Report" edited by C. W. Blaxter and W. E. M. Morris.

Book 3 —"Systems Design for People" by E. Mumford.

Book 2 of the series entitled "Workshop Report" describes the Workshop, organised by the National Computing Centre, which was held from 21-23 January 1970 in a hotel at London Airport. The Workshop (programme detailed below) was intended as a guide for future activities in the project field, principally by obtaining the views of international experts, but also by the exchange of views by all the participants. Reports are given on project activities, including a survey of current practice in the UK in which 300 computer installations selected from the NCC list were invited to comment on their systems by means of a questionnaire. Papers presented by invited speakers are then reproduced, including: Process Control Computer Systems by Mr. C. J. Constable, Durham University Business School; Tangible Aspects of Economic Evaluation by Dr. G. H. C. Ardron, Unilever Computer Services Ltd., The Economic Aspects of Information by Professor J. C. Emery, University of Pennsylvania USA; The Economic Aspects of Behaviour and Social Change by Dr. B. Scheepmaker, Institute of Applied Psychology (Holland); Investment Decisions relating to Computers by Mr. K. Lane, R.T.Z. Consultants Ltd. Finally, the three specialist discussion groups, formed at the beginning of the Workshop, made their reports on, respectively:

Benefits — Chairman, Mr. J. D. Humphries, NCC Ltd.

Costs — Chairman, Mr. C. M. Reddington, Liverpool Corporation

Behavioural Factors — Chairman, Mr. A. W. Pearson, Manchester Business School

Workshop Programme

Wednesday, 21st Jan.

INTRODUCTION

Dr. T. A. Duerden—Chairman, Project Committee

CURRENT PRACTICES

Chairman—Professor A. Mercer

Speaker—Mr. G. S. Dorey

Presentation of the results of the general survey of current practices in the United Kingdom.

Speaker—Mr. C. J. Constable, Durham University

A special survey in the process control field.

THE INVENTORY MANAGEMENT STUDY

An NCC sponsored study group under the chairmanship of Mr. F. Land of LSE, presented the results of their study of the use of computers for inventory management.

THE WORKSHOP STRUCTURE

Speaker—Professor A. Mercer

An indication of how the workshop was structured to consider the problems encountered in the Inventory Management Study.

TANGIBLE ASPECTS OF ECONOMIC EVALUATION

Chairman—Mr. G. B. Esselmont

Speaker—Dr. G. H. C. Ardron, Unilever Computer Services Limited

The costs and benefits which are apparently readily measurable for computer systems and how user departments might be charged for the services. For example, the use of computers for invoicing could be considered in this session.

GENERAL DISCUSSION

Chairmen—Lt/Col. J. A. Burton, Mr. G. S. Dorey, Mr. G. E. Williams

Reporters—Mr. C. M. Reddington, Mr. J. D. Humphries, Mr. A. W. Pearson

Participants were divided into chaired parallel sessions, each discussing prepared themes for all proposed specialist groups and the matters raised during the earlier talks. The objective of these discussions was to settle the basis for the specialist groups, and to enable participants to decide which one(s) they might wish to join for later discussions.

Thursday, 22nd Jan.

THE ECONOMIC ASPECTS OF MODELLING

Chairman—Professor A. S. Douglas

Speaker—Dr. P. J. Coen, Logica Ltd.

The costs and benefits of using computer-based mathematical models for decision and control purposes. Computer systems for competitive bidding, commodity purchasing or inventory control were examples considered in this session.

THE ECONOMIC ASPECTS OF INFORMATION

Chairman—Dr. J. Hawgood

Speaker—Professor J. Emery, University of Pennsylvania (USA)

The costs and benefits of having computer-based information systems. Producing detailed sales reports was included in the examples of such applications.

THE ECONOMIC ASPECTS OF BEHAVIOUR AND SOCIOLOGICAL CHANGE

Chairman—Mrs. E. Mumford

Speaker—Dr. B. Scheepmaker, Institute of Applied Psychology (Holland)

The sociological changes which take place in an organisation when a computer is installed. For example, what are the costs of training the management to use a system and what are the penalties of not doing so?

SPECIALIST GROUP DISCUSSIONS

Chairmen—Mr. C. M. Reddington, Mr. J. D. Humphries, Mr. A. W. Pearson

Reporters—Mr. C. W. Blaxter, Mr. R. Boot, Lt/Col. W. E. M. Morris

Participants divided into three groups. Each discussed themes settled on the previous day, and in the light also of the day's lectures.

Friday, 23rd Jan.

INVESTMENT DECISIONS RELATING TO COMPUTERS

Chairman—Mr. E. J. Howe

Speaker—Mr. K. F. Lane, RTZ Consultants Ltd.

The costs and benefits considered by the previous speakers should be integrated when making an investment to use a computer-based system. For example, is it necessary to carry out a risk analysis or will a discounted cash flow calculation be adequate?

SPECIALIST GROUP DISCUSSION

The specialist group discussions considered whether they wished to modify their views in the light of the talk on the problems of making an investment.

FINAL REPORTS

Chairman—Dr. T. A. Duerden

The three specialist group chairmen each made a report, and answered questions.

LUNCH WITH FORMAL CLOSING OF WORKSHOP

Dr. A. A. Robinson, Director, NCC Limited

Summaries for other books in the series appear at the end of this publication.

SECTION 1

Reports on Project Activities to-date

The following comprise summaries of reports made on the two major areas of work undertaken to-date.

Survey of Current Practice in the United Kingdom

Mr. G. S. Dorey

A survey of relevant current UK practice was agreed by the Project Committee as being a necessary step towards knowing something of the 'state of the art' generally and to identify a range of computer users with whom subsequent studies and co-operative work could be conducted.

In mid 1969, it was found that The British Computer Society and The British Institute of Management had similar surveys in mind. Agreement was reached on a joint exercise and a small working party comprised of a representative from each of the three relevant parties, with an NCC regional officer as secretary, designed a questionnaire.

THE SAMPLE

The questionnaire was sent to 300 computer installations selected from the NCC list, the distribution being arranged under BIM auspices. A covering letter was addressed to the Managing Director, as it was hoped to obtain the views of general management rather than those of the specialists responsible for data processing.

In due course, 71 completed replies were received – a response of 23% – after a reminder had been sent, and 40 companies had declined to participate. A second sample was taken later, entirely from the NCC membership; and out of a total of 267 questionnaires distributed, 49 completed replies were received – a response of 18%.

The two sets of completed replies, comprising Lists A and B respectively, were summarised and the results distributed to the people who had co-operated in answering.

Questionnaire, and Summary of Replies	*List A* (total 71)	*List B* (total 49)
	Number replying 'yes'	
1. Do you evaluate your computer activities in the same way and with the same criteria as other investments?	38	25
2. What method of evaluation do you use?		
Return on Investment—DCF	24	12
Payback	14	4
Book return	2	5
Other	16	26
3. Do you justify:		
Computer system as a whole?	49	39
Individual applications separately?	40	22
New applications as they arise?	55	37
Other	3	2
4. What costs and benefits do you quantify and take account of in an evaluation?		
Costs		
Hardware	66	45
D.P. staff salaries —development	64	43
—operating	67	44
Other staff salaries (e.g. user departments)	47	37
Parallel running	37	21
Learning	41	24
Data conversion	54	38
Indirect costs (occupancy etc.)	39	34
Direct services (stationery etc.)	59	38
External services	42	29
Software packages	27	20
Staff recruitment	31	17
Other	7	7
Benefits		
External revenue	28	25
Direct cost savings —clerical	63	45
—other	57	42
Reduction in investments (e.g. inventories)	45	24
Improved cash flow	31	16
Improved service	55	42
Improved information	62	40
Intangibles (e.g. goodwill)	19	16
Other	10	7

	List A (total 71)	*List B* (total 49)
	Number replying 'yes'	
5. Do you review performance against the justification		
For costs?	46	32
For benefits?	42	28
For completion of project?	38	23
For efficiency of project?	34	26
Other	2	2
6. Do you review existing justifications as circumstances change?	42	28
7. Do you charge development, operating and other costs of individual projects to their users?	30	32
8. Who carried out your latest computer project evaluation?		
Financial staff	32	15
D. P. staff	52	39
Consultants	8	3
Other	7	18
9. Type of industry (Board of Trade group)—		
Agriculture, Forestry, Fishing	2	—
Mining, quarrying	1	1
Manufacturing—		
Food, drink and tobacco	7	2
Coal, petroleum and chemicals	13	2
Metal manufacture	4	3
Engineering	23	3
Textiles, leather and clothing	3	2
Other manufacturing (bricks, pottery, glass, cement, timber, paper, etc.)	10	1
Construction	2	1
Transport and communications	2	1
Distributive trades	4	3
Public Administration	—	27
Other	2	—
10. Is this your 1st	30	24
2nd	28	14
3rd	10	4
or later computer installation?	3	4

	List A (total 71)	*List B* (total 49)
	Number replying 'yes'	
11. How long has your current machine been installed?		
12. How many computers are in your installation?		
1	49	34
2	8	4
3	4	2
4	5	1
5 or more (maximum 20)	3	5
13. What are your annual data processing costs in thousands of pounds?	66 replies totalling £16,649,000	48 replies totalling £14,094,000
14. Data Processing costs as a % of turnover?	All in range insig.—4.5, most in range 0.9—1.0	All in range insig.—4.0, most in range 0.3—1.0
15. How are your data processing costs broken into:		
% Hardware	(Range 23—71)	
% Operating staff % Development staff % Other costs	Replies not analysed. —many grouped	

COMMENTS ON THE REPLY SUMMARY (LIST A ONLY)

Method of evaluation

38 companies used the same method of evaluation as for other investments. Return on investment was used by 24 companies, payback by 20 and book return by none. Not very many DCF rates used were quoted but these varied between 10% net and 30% gross. Payback rates varied surprisingly between 10% and 100%. 16 companies used other methods, many of which were adaptations of the payback method. ("hunch, with a financial bias" wins the prize for honesty). 10 companies used two or more methods: most frequently one method for the project as a whole and a different method for individual projects. None mentioned percentages of sales as a method of evaluation although it seems to be widely used as an assessment of total DP costs.

49 replies said they justified the system as a whole, and of these 19 replies related to the first installation, the remaining 30 to second or later installations. 40 companies justified individual applications separately and 55 justified new applications as they arose. We did not attempt to relate this question to the methods used, nor did we ask for the types of application involved.

Costs and Benefits

The benefit most often quoted was improved information—extremely difficult to quantify. The other most common benefits, as might be expected, were reduction in clerical and other direct costs and improved service. Reduction in investments and improved cash flow were less common but were still quoted by about half of the companies. "Conformity with group systems" was twice quoted as a benefit and this may well be increasingly a common reason in large companies. A further benefit quoted was improved security.

Of the costs listed, most seemed to be taken regularly into account, even by those not answering the questions on evaluation. Parallel running, learning and recruitment were least often catered for.

Review of Performance

About 40 out of the 71 companies review the justifications after completion of the project, not always on a regular basis.

Charge-out

Only 30 of the companies quoted that they charged out costs to users, and many of these charges were arbitrary apportionments of total costs. Detailed costing of projects is essential for proper justification and frequently also for charging.

Latest evaluation

In 52 companies the latest evaluation was carried out by DP staff and in 32 by financial staff, although 22 of these were in conjunction with DP staff. In only 8 cases were consultants used.

Cross-section of companies replying

23 replies came from the engineering industry, 13 from coal, petroleum and chemicals, 10 from other manufacturing.

In 30 cases the reply concerned their 1st installation, 28 concerned the 2nd, 10 the 3rd, 2 the 4th and in 1 case the installation concerned was their 6th.

49 companies had a single computer in their installation, 20 had more than 1.

66 replies gave data processing costs totalling £16,649,000—an average of £252,000: but this was distorted a little by one company quoting costs to the nearest £ million. As a percentage of sales the costs varied from insignificant to 4.5% with 0.9 to 1.00 as the most common. Some of the answers given gave improbable sales figures when related to total DP costs.

Hardware costs quoted ranged from 23% to 71% of total DP costs and average well over 40%. This seems a surprisingly large proportion of total costs.

Respondents

Although the questionnaires were sent in most cases to the Managing Director, the respondents covered a wide spectrum. 18 were DP staff, 16 from finance and accounting, 9 each from administration and management services.

Further co-operation

A gratifyingly large number of companies expressed a willingness to co-operate in further studies and these will be followed up later when any development of this project has been decided upon.

Results of the Inventory Management Study

Mr. F. Land, Mrs. E. Mumford, Dr. J. Hawgood, Mr. C. M. Reddington

Note:—This summary consists of an extract from the full report of the Inventory Management Working Party dated November 1969. This report was circulated to all participants for perusal before the workshop, and a revised version forms Book 1 in this series.

THE WORKING PARTY'S BRIEF

Initially the Working Party was set up under the auspices of the main project to recommend techniques for the economic evaluation of computer systems in the specific application area of inventory control. The choice of a single application area for study was based on the assumption that any method of evaluation would apply to a limited type of computer use only and that separate methods would have to be developed for each area. One question to which the Working Party sought an answer was whether this assumption was valid or useful.

After initial discussion, the Working Party felt that it could not develop techniques independently of a review of current practices, nor could it progress on any line of development without a concurrent check with actual computer users that these developments were in the right direction.

It soon became clear to the Working Party that a considerable amount of research and discussion is currently taking place into various techniques for the evaluation of investment decisions. These centre around the measurement of rates of return on investments and use techniques such as discounted cash flow, displaced costs, etc. Whilst the choice of techniques for evaluation in this sense is important also in decisions relating to computer projects, the Working Party felt that they should concentrate their attention not on these questions but on the identification of those elements of costs and benefits which would have to be treated as inputs to an investment decision model. The main task, then, would be the development of techniques for the measurement of these costs and benefits.

THE METHOD OF RESEARCH

The Working Party developed a number of concurrent and interlinked strands of research.

(1) A search of the literature on the subject of evaluation of computer projects. The basis for the search was a lengthy bibliography produced by Aslib. At the same time use was made of the literature to provide both confirmation of the Working Party's thoughts, and ideas for further developments. In general, however, the literature proved to be of limited value; it concentrated, largely, on current evaluation practices such as discounted cash flow.

(2) The Working Party attempted to define the factors, economic and otherwise, which an organisation should take into account when considering the introduction of a new computer-based inventory control system by drawing up a list of factors which might stimulate the organisation considering the change from its present system. Each factor has associated with it a list of the benefits which an organisation might look for when changing to a computer-based system as well as a list of the negative effects of making the change. The Working Party also attempted to give a weighting to each of the stimulating factors to suggest its importance in making a decision to change systems.

In order to check on the completeness of this list and to help in assessing each factor the Working Party invited a number of organisations who are known to have used computers for inventory control to discuss their own system of evaluation with the Working Party.

(3) As soon as a stimulating factor sets in train the possibility of changing systems, costs are incurred in—

(a) considering whether or not to embark on the process leading to a change of systems (feasibility study).

(b) designing a new system, including the choice of software and hardware.

(c) implementing a new system.

(d) operating and maintaining a new system.

The Working Party tried, under each of the above headings, to identify the costs which might be incurred, again checking on their applicability and on the method of costing and measurement used, with the organisations volunteering information. Some of the variables are directly measurable, whilst others, particularly those concerned with aspects of human resources such as loss of morale, are much more difficult to assess quantitatively. Indeed, it became clear that many of the cost variables identified by the

Working Party were not taken into consideration by our industrial informants for a number of reasons, including the following:—

(i) because they were not recognised.

(ii) because it was felt that they were not measurable.

(iii) because no suitable method of costing was available.

(iv) because it was thought to be impossible to disentangle on the cost side (and indeed also on the benefit side) the effects of the change to computers from the effects of other environmental and economic changes.

(4) In order to continue its discussions with industry, the Working Party decided to prepare a structured questionnaire based on the stimulating factors and the cost and benefit variables. It was intended that the questionnaire should be used to help in a study of organisations which had a computer-based inventory control system. Further, the same structure of enquiry would be used for a longer term study of organisations initiating or altering any computer-based system.

(5) The Working Party is developing a computer model of an inventory control system incorporating the variables related to costs and benefits which have been identified by the Working Party. The model is intended to be used as a tool for quantifying costs and benefits not susceptible to analysis by other methods.

TENTATIVE CONCLUSIONS

The Working Party's research is at a point where it is possible to conclude that further research should be carried out and where it is possible to suggest the questions this research should seek to answer. The Working Party has developed a research methodology which should enable the further research to go ahead. In the meantime, certain tentative conclusions are drawn:—

(1) Whilst inventory control raises certain specific problems of cost and benefit measurement, the majority of variables identified by the Working Party are probably common to most applications although their actual weighting may vary from one application to the next. Hence the Working Party concludes that the original hypotheses regarding separate application areas is not valid.

(2) Many 'appraisal costings', i.e. costings carried out as part of the feasibility study, if done at all, neglect important variables and are rarely rigorously checked within the organisation, and to a surprising extent do not come under the scrutiny of the accountants.

(3) The 'out-turn costings', i.e. costings carried out after the implementation of the systems, are frequently left out altogether, or are made to justify

decisions taken without attempting to measure all the relevant variables, nor do they attempt to take into account the effects of other environmental or economic changes.

(4) Rigorous cost controls during the implementation and operating stages of a new system are rare, and if carried out tend again to be carried out for the purpose of self-justification rather than control.

(5) Whilst costing techniques in measuring direct expenditure and directly attributable savings, e.g. reduction in the number of clerks employed on the job, are common, there are few satisfactory methods of assessing, other than qualitatively, the impact of so-called 'intangible' benefits, e.g. loss of morale or disorganisation resulting from change. The methods for evaluating human resource costs are still in their infancy and are not seen as relevant to an economic justification of a new system.

QUESTIONS FURTHER RESEARCH SHOULD SEEK TO ANSWER

The on-going research should seek to answer the main question:—Is it possible to devise a general system for the economic evaluation of computer-based projects? Answers to some of the questions posed below will help in the development of such a system:—

(1) Which of the cost and benefit variables identified by the research are subject to objective measurement, both in the sense of 'appraisal' and 'out-turn' aspects? Note that Götterer has attempted to demonstrate that it is not possible to cost the benefit of a particular information stream to a decision maker. Where the variables are measurable it is necessary to lay down rules for their measurement.

(2) Which of the variables in any application area are worth measuring? Since costs are involved in the process of measurement, some of the variables may not be worth measuring.

(3) The reasons which cause inadequate cost-benefit analysis to take place.

(4) The nature of the controls an organisation needs to have in order to estimate (at the appraisal stage) and to cost the variables.

(5) The nature of the expertise which an organisation needs to have in order to exercise these controls.

SUGGESTED RESEARCH METHODS

It has become clear to the Working Party that any research method which limits itself to the historical reconstruction of costs incurred when introducing a computer-based system will arrive at inaccurate conclusions. Once an EDP system is installed, firms are reluctant to admit that financial savings have not come up to expectations, and by wishful thinking will justify the correctness of their EDP decisions. The Working Party is therefore considering the use of the following methods:—

1. *Questionnaire Survey* into current practice and attitudes, in a sample of firms selected from the preliminary Current Practices postal questionnaire. The questionnaire which has been developed by the Working Party will be used as a basis for this survey.
2. *Development of standard costing practice* in consultation with the relevant professional body.
3. *Model-building and testing* of the computer model.
4. *The sponsoring of a workshop and continued liaison,* with people doing research in the general area.
5. *Pilot applications of the technique* to real evaluation problems in commercial and non-commercial organisations.

SECTION 2

Synopses of papers presented by invited speakers

The following synopses cover the formally presented papers, and in the main comprise edited versions of the invited speaker's notes and/or transcripts from tape recordings.

Significant points made in discussion following each paper are given on a question and answer basis after each synopsis.

Process Control Computer Systems

Mr. C. J. Constable

AIM OF RESEARCH

A research project was undertaken in a major British Industry to investigate the progress which has been made with process control computing systems. All the systems take information directly from some part of the manufacturing process and either (a) log the information, (b) carry out calculations and give information to an operator, or (c) have control of the process. The research is aimed:—

(1) To establish the nature and extent of the installation financial evaluation.

(2) To determine the major reasons for installing the computers. Reasons which were quantified in monetary terms, and those which were not quantified, were both established.

(3) To determine the extent to which the original objectives laid down for the system had been achieved, and to discover the nature and extent of any formal post-installation financial evaluation.

(4) To determine the nature of the managerial problems which arose in connection with the computer systems.

(5) To obtain the opinions of all those people who had been involved with the installations on various questions relating to: financial evaluation: the impact of the computer on the organisational structure: the problems associated with planning and installing computer systems: and the extent and nature of future computer installations.

RESEARCH METHODOLOGY

Information was collected through the use of two questionnaires and a series of interviews. Two questionnaires were used in order to separate what were essentially "facts" from "opinions".

The first questionnaire was completed once for each installation, usually by someone from the systems group but frequently by more than one person. It sought to establish such facts as the costs of the system, and the figures which were produced in any pre- or post-installation evaluation reports. The second questionnaire was designed to collect both fact and opinion, and was completed by at least two—and in some cases up to five—people, for a separate installation. The basic two people from whom information was sought were the Chief Computer Systems Designer connected with the installation, and the Production Manager responsible for managing the plant containing the computer systems. Information was obtained on such things as: which groups of people were considered to be involved in various stages of the installation: the respondent's opinion as to the major reasons for the installation: his opinion on the extent to which the installation had achieved the original objectives: what he perceived to have been the major problem areas: and his opinion of various general statements about computer process control.

Every person completing this questionnaire was interviewed for between half an hour and one hour, in order to try to find any problems encountered in completing the questionnaire, and to permit elaboration of any points where the respondent had strong feelings.

RESULTS OF THE RESEARCH

In this brief outline it is not possible to give a detailed account of the results of the research, but a number of points are perhaps outstanding and can be mentioned.

(1) The installation financial evaluation had been carried out for approximately two-thirds of the installations. However, by and large, the techniques used were somewhat unsophisticated.

(2) Although there were 21 installations in operation, in only eight had post-installation evaluation been carried out formally. In the case of four of these the people concerned felt that the results were not very meaningful because it was extremely difficult to relate cause and effect in terms of improvements.

(3) Benefits such as better information and more speedy information, which had not been quantified in monetary terms at any installation, were even considered to be major reasons for installing the computer at many installations.

(4) There were quite considerable differences of opinion between production people and systems people about the extent and nature of the problems

encountered at installations and the extent to which the original objectives had been achieved. In almost all cases production people considered that problems had been more severe, and installations less successful, than did their systems counterpart.

(5) It appeared possible to categorise installation types on a success-failure range on the basis of the level of problems encountered and a subjective assessment of success achieved by those involved in the installation.

PROBLEMS ENCOUNTERED IN CARRYING ON THE RESEARCH

For the purpose of this Workshop it seems useful to outline some of the problems which were experienced in conducting the research. The research was carried out as an official piece of work within the industry and this resulted in the highest level of co-operation being obtained. I think it is extremely doubtful that a private "Researcher" would have been able to obtain much of the information, in particular the financial information, nor would he have experienced the same co-operation. A number of problems did however emerge and these were as follows:—

(1) There was a tendency to misinterpret questions in the questionnaire even though considerable discussion took place during their compilation. Without the subsequent interviews some of the information might have remained incorrect. Interviews are, I think, essential and I do not believe that information can be safely collected from questionnaires alone if a large number of installations are to be compared with each other on certain points.

(2) In spite of the official nature of the survey, difficulty was experienced on a number of occasions in obtaining detailed information about costs and benefits. This difficulty naturally tended to be greater the older the installation.

(3) Related to this point was the problem of finding people who were able to recollect all the stages of the installation. This was particularly true on the systems side where there tends to be a fairly high turnover of personnel.

(4) The fact that the installations range in age from one which was nine years old to those which were currently being installed made comparing of certain information very difficult.

SUMMARY

Although this research was somewhat special in that it was carried out in a single industry for a particular type of computer, I think that some of the methodology used and lessons learnt might well have more general applicability to the overall question of evaluating computer systems. It is clear from this work that much remains to be done in this area, and that any progress which this Workshop can make to the state-of-art would be most welcome.

Tangible Aspects of Economic Evaluation

Dr. G. H. C. Ardron

As I see it, my task is not to go through case histories of computer applications to discover which were and were not profitable, but to encourage discussion by reviewing the use of computers in commercial work; in other words, to see where we have got to in deciding the criteria on which we pronounce an application to be successful, and how we charge out for computing work.

THE 'SAVE MONEY' AND 'MAKE MONEY' STAGES

In the early sixties all computer applications were based on the 'save money' principle. If you install a computer, it will save you more than its costs through staff reductions and will provide a hedge against clerical inflation. This is no longer fashionable; we have reached the 'make money' stage. Install a computer and 'make money' by stock reductions, by better decisions made more quickly and so on. Quite cynically I imagine this second stage has been evoked by the computer manufacturer who saw his first flag being tattered by the administrative trade winds.

Let us examine for a moment the first stage, the 'save money' stage. In any large company with a reasonably complex administrative system, it was becoming obvious by 1963 or so that the quality and quantity of labour available for clerical work was inadequate to serve the needs of the business. Product proliferation was making stock recording and invoicing more complex and more prone to error. Within the company someone would mutter "computers" and, egged on by good salesmanship from computer manufacturers, a feasibility study would be got under way. The level at which that study was pitched and the degree of backing from top management—as much as anything else—could determine the fate of the study. Incidentally, most of these applications grew up in the accounting area of the business. In general terms the study looked at, say, two aspects—Invoicing and Stock Records—and evaluated the clerical labour already employed as a total cash figure. Various elements were deemed to be suitable for mechanisation, and an estimate of clerical effort on these repetitive tasks was made and evaluated in cash terms. This was available to pay for the computer and for data preparation, on the assumption that clerks would be displaced by the computer system.

The installation of a computer carries a heavy cost in the development of systems and programs, which have to be taken into account and paid for in the overall cash flow, so that DCF techniques were used to show the overall rate of return on the project.

For a largish company, the round figures might have been somewhat as follows:–

	£K
Total administrative cost for 1,200 staff, per annum	1,000
Jobs to be mechanised, equivalent to 300 staff	250
Cost of computer installation and data preparation	150
Gross saving per annum, therefore	100
Development cost over 2 years	250

Using a calculation over 5 years, and allowing say 4% per annum for clerical wage inflation, the project would have shown a DCF figure of 35; pretty good going, by most standards. Behind these figures, however crude they appear to be, was a lot of detailed work. Estimates were made of the number of lines in each customer address, the number of customers who had double addresses, and the number of lines per invoice. The number of invoices/year would be known, and all these would be taken into account in making the estimate of savings.

The computer configuration would be designed to take account of the current situation and of any expected increase in lines per invoice, increase in number of accounts etc. *but* in all probability no one would calculate the clerical costs associated with this increase if the computer was *not* installed.

A couple of years after the application has bedded down, if you take an audit, you may well find that the staff has not decreased in line with the expectations of the original plan, that the number of lines/invoice has increased at least as much as had been expected, and that at this work level, although the computer should only be on two shifts, it is pretty well bursting its seams on three.

What has caused this to happen? I believe the following things:—

(1) the amount of work easily mechanised is less than at first believed. Clerks, however mini-minded and skirted, make a series of small decisions not easily uncovered in a feasibility study, and the mechanisation of these elements can prove costly in both development and computer running. Some may be tacitly left in the manual area. This increases both clerical and computing costs above the estimate and, perhaps more important, tends to 'fossilise' the system.

(2) the increase in numbers of lines per invoice and the number of accounts will have 'crept up' on you almost un-noticed, and it is quite a shock to discover that there is a substantial increase in work load that has arisen unheralded. This again increases both computing and clerical costs—and deprives you of the chance to save clerks.

(3) the computer has not performed according to the manufacturer's specification, which has eaten into that spare capacity you thought you had.

(4) the computer system will have released new urges among its users, who will have demanded and, one hopes, been provided with the information hitherto impossible—say sales statistics or new stock re-ordering systems etc. This will have caused another increase in computing and clerical costs.

The computer people too will have helped this increase, because when the base load is done there will be a staff of analysts and programmers for whom work has to be found.

At this point there is I believe only one sensible course, and that is to do another study—a sort of feasibility study in reverse—to decide what the present system would have cost had it developed to the present stage on an entirely manual basis. I have done this, and it's a salutary lesson involving the hypothetical building of new offices, and the recruitment of staff that don't exist. And it demonstrates that, at the now current level of administrative effort, the computer is a good deal cheaper than would be its manual equivalent. This brings me to a fundamental point that I have been pondering for some time—is there a sort of tacit level of administrative cost tolerated for a manual system, and an entirely different level for a computer system? It is for sure that the levels of sophistication are different for each system. Or is it that a manual system can only be reasonably contemplated at a fairly simple level, and that computer-type systems manually-operated are simply not even contemplated? Obviously the processing speed of the computer is a major factor in this argument. There seems to me to be some kind of unwritten law about what can be tackled, and in expense terms, tolerated by a manual system—a sort of administrative 'sound barrier'. Once that barrier is broken—by a computer—is there another level of expense sophistication which companies will reach? It will obviously not be the limit of technology, because the academic and government sectors (e.g. NASA) have gone way beyond anything that is contemplated commercially.

This brings me to the 'make money' aspects of the computer. Putting on to a computer—especially with the great sizes of memory now available—work like invoicing, ledgers, stock control, wages etc. brings into being a mass of data to work upon. Systems and programming effort is required to develop new types of sales analysis, marketing statistics, labour cost control, inventory control etc—but these can be done. Line management is asked to put a value on such information—"What it's worth". Once the basic data is in the machine these secondary operations can be done for little machine cost—though the development cost may be high.

In certain fields the 'pay off' can be quickly established. Raw materials stock control can be extended to linear programming of product-mix formulae, and the cost-benefit fairly readily established. In the area of production planning a similar calculation can be made, but this is often more difficult to evaluate. It is certainly more complex to develop and is likely to cause antagonism among production management, who will see it as 'whittling-away' of their authority.

It is in the area of sales and marketing that cost-benefits are more difficult to establish, because the facts are known with a lesser degree of certainty. When men landed on the moon, the technical problems of the descent were enormous, but at least it was known that the laws of gravity would not change, and that they were dealing with a stable situation. In the sales field the laws are imperfectly understood and can be changed by a competitor's promotional schemes, local unforeseen idiosyncracies and a host of other factors. It is therefore difficult to determine whether the computer information increased market share by two points, or whether other and unmeasured forces were at work. The salesman is glad of his new and more up-to-date information, but is reluctant to put a value on it. The cost-benefit is hard to determine at this tactical level. At the marketing level, the area of strategy, there is an even looser correlation between information and benefit. Market research gives pointers, and—due to the power of the computer—more accurate ones, but the area of uncertainty is great in cost-benefit terms.

The 'in things' today are 'data bases' or management information systems. These imply an attempt to marshal collected information in a way that will benefit the business. We are all struggling with these intricacies, some by trying to develop a comprehensive but logical sequence of information sifting, others by trying to devise new ways of assessing random information for subsequent collation and reduction. Whatever the means, and to some extent whatever the cost, this secondary phase of computing is with us. The 'band waggon' is rolling, and for major companies, it will be a brave man who opts not to jump on it. Somewhere there will be a limit to what businesses are prepared to pay for this new level of sophistication.

Somewhere a *new* barrier will be established! The technologists are having a field day at this time, and are using their new-found technical freedom to develop new ideas. But the pay-off must come in economic terms. If everyone develops super models of the economy and the market place, then every move will be monitored, and countered, and a stalemate could develop — a new and expensive level of stalemate. The unexpected and the unlikely will prove to be the real pay-off for the very few who will continue to beat the system.

In most of the commercial applications that I have been associated with the costs have exceeded expectation, but then so has the volume of work processed: and so long as there has been real management involvement, the applications have not gone into the doldrums, but have been used as the basis for secondary work. The original application has 'washed its face', and operating management are learning to use a computer system as an aid to decision taking. They seem to have one major fear, however, and that is that the computer puts them in a strait-jacket. When they realise how much it costs to develop a Sales Statistics suite from a ledger programme, they worry about what happens when they want to change their minds. Everyone fully appreciates the advantage of aggregating invoices for a supermarket chain and arranging automatic debit transfers through banks. This is a stable requirement that the computer can readily meet. Operating management do require flexibility in their information systems, and I believe it is up to computer specialists to devise ways of meeting this requirement.

CHARGING AND COSTING THE COMPUTER FACILITY

These are in fact two aspects of the same problem. You cannot charge for something you cannot cost, and in any case a costing system is a vital measure of the internal efficiency of a computer department.

I should like therefore to deal with the principles of computer costing first, and it is only principles that are important, because accountants can always design a mechanism for applying those principles—and in my experience always come up with a bill bigger than any that was at first envisaged. In a computer company that stands alone as a separate entry, costs are easily identifiable because they all have to be paid for directly by the unit; but in any 'in-house' installation the computer department benefits from a wide range of company services that it shares with other departments. These should be identified because otherwise the computer benefits from marginal subsidies, and true costs cannot be established. The areas I am thinking of are, for example, canteen subsidies, personnel services, typing and administrative services, and the hundred and one other shared overheads. A computer overhead charge can be established in a variety of ways, from a purely arbitrary allocation through a mechanism depending on numbers employed, to a very sophisticated method of sectional allocation. Whatever system is adopted, some overhead charge should be established, to be broken down over the various sections of computer department as an 'on cost' to the direct costs of work being done.

Within a computer department there is one easy distinction, between hardware and personnel. Within the personnel section there is again a fairly clear cut distinction between operating, applications and development.

Operations personnel can be clearly identified to the computer itself, to data control, data preparation etc, and present no real control problems because their work can be measured and cost controls established. Programmers are less easy to control because their work involves two factors, quality and quantity. Quantity can be established as so many statements per day or per week, but this is no real guide if the statements are poor and result in poor machine efficiency. In my view the best way to handle programmers is to control them within their own specialism, and by using the different levels of supervision to monitor both quality and quantity within the limits set by project targets. It is important, too, to establish the relationship between effective working time and those ubiquitous meetings that can be self-generating and delay implementation dates. As far as I can tell, one can expect from a programmer 38 weeks of effective work per year, allowing for holidays, sicknesses, courses, delays and inevitable meetings.

After overhead loading one can then establish a cost per week, or per hour, broken down if need be to different levels of expertise.

Analysts are even more difficult to measure, because their rate of working is often determined by the level of sophistication of the client. If the analyst has an educational role to play, and this may well be the case in a first application, his rate of effective working will be slow. In a sophisticated environment analysts can work quickly and effectively. Again, I believe the most effective cost controls are those exercised by management within the systems analysis section, on much the same lines as for programmers. Analysts and programmers are primarily concerned with projects for which costs and charges have to be established. An adequate feasibility study will establish the likely work content of the project, and hence the cost, as determined above.

The translation from cost to charge involves commercial considerations, and hence I can only express a personal view. It is traditional to consider profit in terms of percentage return on capital, but in many computer installations there is no capital in the conventional sense, because the unit comprises people and machines and space, all of which can be considered as rented rather than owned unless the computer is bought outright. And yet a good staff is one's major asset, one's working capital in every sense of the word, and should produce a return of say 15%; thus, project costs should be uplifted— even in an 'in-house' situation—to reflect the use of expensive assets. Bearing these principles in mind, I believe that the development of a project through its various stages should be charged into a sum which is the capital investment in the system. The 'client'—with help from computer department—must then prepare an economic appreciation which will:—

(1) discount the capital over the life of the project;

(2) evaluate the running costs of the system—both computer and manual:

(3) compare this cost with the benefits of the system, and ensure that the difference represents an adequate return on the investment.

One can complain here that I have injected a double profit—one in the computer department and another in the operating department—and yet this is precisely what happens if one employs an outside agency. All too often, service departments within a company or an organisation are costed on a marginal basis and become the poor relations of the organisation without a defined objective. They should be able to earn an internal profit, and be judged against outside agencies, as an overall measure of efficiency. In this way, they have pride of performance in a market situation, and the accounting effort required to set up this situation is amply justified. Operating departments should be fully informed of the methods by which charges are arrived at, so that there can be no misunderstanding of the elements involved.

One can argue that this sort of approach could price the computer out of existence. This will not happen because in a sophisticated environment it is an essential tool. Management will however become acutely aware of its cost, and require its users to quantify their requirements and their expected benefits. We will not so often be in the position of "It would be nice to know", but rather in the position of "It is worth £x,000's to us if you can provide the information". I believe, too, that it will make management take much more interest in the design of systems. They will be more inclined to follow through the logic of the developments they are asking for, to ensure that common sections are utilised by more departments, and they will apply their own initiative to the development of information systems instead of leaving so much of the thinking to specialists. I suppose that all I am saying here is that management, and by that I mean top management, must become heavily involved with computing as one of the commercial considerations of the business. In this way the computer will become an integral part of the business, not a peripheral activity—and management will seriously consider its impact on the organisational structure, and on profitability.

THE PARTICULAR ISSUE OF PRODUCTION WORK

In the costing of computer production work, I believe that similar criteria apply. One has to make a major decision as to whether to say to the customer "This is my price—take it or leave it", or whether to develop a charging system whereby the customer understands what he is paying for. My belief is that the second course is the sensible one, particularly for 'in-house' service installations. Every customer of a service unit is quite certain that he is paying more than his share, so that some other department can be subsidised. This can only be disproved if the customer is given the facts. I believe that the days of charging £x per hour for computing have gone, especially with the introduction of large systems. A major installation may well be involved in 'on-line' working to a customer's terminals, batch working for others—and all of them using a selection of available computing capacity and peripherals. The principle should be that the customer pays only for what he uses, and for the priority that he sets for his work.

There are obviously many production work variants for a large installation, but I should like to choose two examples:—

(1) *Remote 'on-line' terminals*

The terminal should be owned by the computer department, and the rental of the line and terminal charged direct to the customer, without a profit element other than perhaps a small handling charge. This enables the computer department to control the hardware situation, and bring pressure to bear on maintenance problems. There is then no economic advantage in the customer seeking his own equipment. The customer should also pay for private data storage (on-line and off-line) and for the size of computer that his programs require, with an incentive to keep his program sizes small. He should also pay a premium for his direct access facilities. An example of this might be for a medium-sized machine on multi-programming:—

Rental of line and terminal	£800 per month
Rental of disc storage (off-line)	£10 per month
Rental of tape storage (off-line)	£1 per month
Rental of disc storage (on-line)	£0.50 per track per month
Cost of computing @ 30K storage	£70 per hour
Cost of computing @ 60K storage	£90 per hour
Cost of computing @ 90K storage	£110 per hour
Cost of computing @120K storage	£120 per hour

(2) *Batch Working*

Here there seems to be two types of work; the first is the payroll type where a program is used for many departments, and the most sensible way of charging is on a unit basis, e.g. £2 per employee per annum for preparation of monthly salaries; the second type is that of invoicing runs or accounting suites, and here it would be easy to charge on a unit basis—though it may bias the customer's understanding of what he is paying for. I know of one application where from a single input of customer orders, the following operations occur:—

(a) warehouse packing lists and vehicle load sheets are prepared.
(b) stock sheets are updated.
(c) invoices are prepared.
(d) customers histories and rep's order forms are printed.
(e) ledgers are maintained.
(f) sales statistics are prepared.

Obviously a number of departments are interested in their individual costs, and resent the argument that since all the computing work is interlinked, it cannot be broken down. The distribution manager wants to know the administrative cost of his section; sales administration want to know the cost of producing invoices and ledgers, and the sales manager wants to know how much his sales statistics have cost him if he is equally charged with deciding how much they are worth. Accountants will be delighted to tackle this problem on an allocation basis, but it will produce a static system unlikely to reflect variations in the volumes of work in individual sections.

There is a real need to produce an algorithm to cover this charging situation. Our analysts and programmers produce most complicated algorithms for our clients. We must now examine what controls we have within the computer for producing an algorithm that will enable our clients to know what their costs are, and what they are paying for. We cannot ask them to quantify cost-benefits in what is often a complex environment, if we cannot provide them with demonstrably satisfactory costs. The farther we go into integrated systems the more difficult this becomes, but it has to be solved if we are to monitor the costs and benefits of a large computer system.

Q. Would you give 'credit' to pay for necessary parts of an overall system, and what if you impose a system on a department for good overall company reasons?

A. Yes! One part of the system might be distinctly unprofitable to a section, that is you want to put in something which that section didn't ask for. It is unfair to load them with the overall cost of it. This is where you have got to get your accountants to make appraisal decisions. Take utilising spare capacity, for example! You are running on one shift and you have got two to spare, and somebody says "it would be nice to do this, I really can't afford it, but what will you do it at for me", and the reaction is always, "well its marginal anyway." And then you find one day, of course, that your computer has reached capacity, and you have either to throw the system off or buy a new machine. You have got to say to someone—"look, I am going to do this job for whoever it is at a marginal cost, and let it be recognised that this is what I am doing". If I don't use my spare capacity, there is no benefit at all. At least I am gaining a bit of benefit by doing something for somebody.

Q. You said that you regard your DP manager as being responsible for making a return on investment, and at the same time you are responsible for ensuring that your company installs efficient and profitable systems. Is there some conflict between these two objectives?

A. Your DP manager is responsible for translating into computer terms the systems that management requires, and it is up to him as much as anyone to see that economic evaluation criteria are applied. Cost control in the analysis and programming areas lies with his specialist managers within those areas, who must make sure that they are in fact recruiting the right kind of people. I think this is one of the strictures you have to put on. It's no use my programming manager coming to me at the end of the year, and saying "look, I have done a bad job, but then I have got bad programmers." You don't get points for that. It is the job of general management to set the priorities of the DPM's work. I may be controversial here, but I think this is the only way to make the company really know what they are about.

Q. Why do you see a need to cost the DP department's systems research and so forth?

A. Because any good management who has got an application on will always try to increase it. The bright ones will want to make sure they get more than their original money's worth. They will start to want to put more and more on, your costs will go up and unless you have got some kind of sectional costing mechanism, you do not know where you are. You have to ask individual departments to say what the benefits of having something new or extra are, and you have got to be able to allocate to them a cost to set against those benefits.

The Economic Aspects of Modelling

Dr. P. J. Coen

It is important to distinguish between the use of models in helping to assess computer systems, and the use of models to help your management. I propose to say something about both of these aspects, which have some common features in any case.

INFORMATION AND THE MODEL

There is often a feeling about that the more information the better—if only we could get more of it in time, if only we could have it displayed on a VDU set and so on! All very well, perhaps, but quite a number of managers who got it would not necessarily know what to do with it. In fact, if you have got the wrong organisation not only can more information be unuseful but it can be possibly harmful.

For example, in a department store you have basically two types of people; those who are buying the goods with a directive to keep stocks down, and those who are selling them, with a directive to get the profit up. The buyers say they do not know how much they need to buy until they know the prices the sellers set, so the latter will perhaps reduce the price so as to sell more (or increase the price so as to make more profit) and this can have a great impact on stock levels at the end of the month. Clearly, the information set-up must not allow this sort of stalemate situation to come about.

Again, if you process a lot of data, take averages, smooth it and so on and put it out again, you are not really adding very much to the information content. What we need is some sort of information processor, that is a model of some sort interposed in the system. You really cannot afford to ignore the potential of models for your own operations or for the senior management which you serve.

We have to remind ourselves that once you start moving information round an organisation, or changing the way in which it moves, or dragging out new information, you are really getting in deeper than ever and you have got to be careful about it. The trouble is that information is used for lots of things—it is almost certainly used to evaluate the people from whom it is coming, for example!—and you are getting near the raw ends of the nerves when people have to pass up information which will be used to assess their own performance. What people may try to do is to pass on facts so presented that everything appears under control.

SYSTEM SELECTION

Models can help in system selection and some interesting examples in the hardware field are to be found. Before United Steel had a small process control computer delivered for a particular operation, they simulated the operation of this machine on a very much bigger and more powerful one—almost the wrong way round you might say, but the small machine did not exist and indeed some of the control loops timings were so tight that there was at least room for argument about which of the computations could be conducted on this small computer.

A more recent case is the Ministry of Transport's very large vehicle licensing centre to be set up in Swansea, where they have designed a simulation model of the computer centre. They expect to optimise their mode of operation having regard to all factors that affect work throughput. It may seem rather elaborate to go to these lengths, but a major installation of this sort with enormous document-producing loads may show startling savings if handled optimally.

INTEGRATION OF THE MODEL IN THE OVERALL SYSTEM

Models can only realise their possibilities if backed by information systems, and their proper place is embedded within the overall DP system operation. Then people will be using them almost without realising it, we can make the outputs more timely, and have the decisions which should result taken with the full advantage of earliest-possible making. The more advanced oil companies are now moving from their more 'traditional' LP scheduling towards more integrated systems where the scheduling model has a direct interface to an operating data bank updated daily where necessary. When it is time to do the typical grand monthly planning run, the model just picks up the data from the bank knowing that the data is as up-to-date as possible.

If we are able to organise our planning models in such a way that they will use and/or produce data required for other purposes anyway, then we are getting towards something sensible, and we can begin to see—admittedly with the issue of cost allocation to face—the coming together of the 'normal' DP operation and model running within an overall management information and planning system. If, say, for production planning, one is putting on file data from invoicing or billing activities, it may well be quite different economically now to do production scheduling 'on the back' of this because a substantial part of the latter's cost can be getting primary data on to file.

OBJECTIVES AND MEASURES OF PERFORMANCE

Very few of the management I have come in contact with in this country are really prone to systems thinking in the American sense. Few people seem to have the time, the motivation or the facilities to think through their business problems really thoroughly. Models can help provided we know very clearly what are the objectives they are to lead management towards, and what measures of performance apply.

Apart from the obvious financial ones, there may be social measures like not upsetting the boss, saying the right things in public about the company, and maintaining the image of the organisation. I think that the measures are relative to most organisations; in my own, for example, there is very little problem in identifying them—they are:— to survive, to grow, to remain viable—but we are small so it is simple and manageable. It is in the very large organisations and in the non profit-making organisations that the problems of measure and performance become really difficult. How do you 'measure' the Ministry of Technology or The National Trust?

Not getting the priority of objectives right, or permitting sectional ones not compatible with company ones, can be a disaster! Going for a higher share of the market may be a crazy thing to do in terms of profits if that is what you are worried about, and I have seen people on the production side whose only concern was production level, regardless of the quality or 'width' or regardless of the need to sell it. I worked in the steel industry before I came into the advisory business, and I know of one case where they used to save up the scrap for weeks and pile it on the blast furnace to get a production record—a fantastic measure of performance, but never mind the fact that metal costs had gone up, that linings had been torn out of the furnace and so on. An article in the 'Harvard Business Review' commented on the dangers of using 'return on investment' as a performance for criterion profit centres which were not really profit centres, or profit centres that were independent of others.

Using the wrong measures of performance can really be disastrous in terms of people's motivation and their rating by themselves and others. Trying to isolate or separate things that are inseparable can be nonsense, and you see many cost departments and computer departments producing loads of standard cost information and putting to managers information which is not within their control—and then beating them over the head because, say, costs of production have gone up!

What modelling can do in a useful and quite 'uncomfortable' way is to force us to think about our objectives and about the relationships between things we have to deal with. You can get some upsetting knocks to your beliefs this way! Once we have got a model which is valid in some degree, it is still only a simplification of reality, so it is going to be wrong somewhere. Simplification is perfectly valid as long as everybody is aware of what the simplifications and assumptions are. The thing to do after we have developed a valid model is to test alternative strategies or alternative actions, and to get used to the idea of filtered data where we work to the succinct outputs the model provides, and get to trust it in highlighting exceptional conditions and stimulating management reaction and provocation.

What the model can also do is to bring together, say in the steel industry, the technical and accounting information of the iron-making technologists and the accountants respectively. Previously, the accountant might say, "use this one because it is only a tenth of the price of the one so far used", while the technical man might reply that the new one will ruin his furnace. With the model, both can look at the 'trade off' and hopefully agree a compromise or optimum solution. Another thing that the model does is to encourage or even force consistency. Nobody would claim it is good to be consistently wrong, but very often poor performance is due to erratic behaviour. If we can get people using the same tool, however imperfect, at least there is a common basis for value judgements.

I think the biggest single issue, apart from the one of producing the technique to solve the problem, is in convincing management that modelling can help and is a viable proposition in the case in question. In analysing the successes I have been associated with (and there have been failures as well), the common thread was that there was a man on the management side who knew what the problem was, who took an active interest in it and had the power to do something about it. It is obvious but it has taken me some six years of 'data collection' to prove this conclusion.

Q. Would you care to comment on the issues in teaching senior management to use management information, and to contribute to the model and its improvement?

A. In a case I was involved in, it was found that they could not model the decision processes as they happened, so to speak! They could put in the decision processes that ought to be logical but completely failed to model the decision makers *in situ*. So they did a sensible thing, and actually built the people into the simulation. They actually got the relevant men into the room, confronted them with certain information from part of the simulation and asked them to take the decisions for input into the model again. They gained quite a knowledge of the processes, and the system as a whole. In some cases you will find people who set up illegal communication channels to keep the company going, for example.

Q. I certainly agree with you that O.R. models by and large are successful because they are embedded in the information system, but what disturbs me (at least in the United States) is that in educational programmes, and organisationally within firms, this recognition is not made. Educational programmes and O.R. communicators often have very little to do with the computer, and *vice versa*, and typically the OR group is separated some distance from the DP group. Is this so in the UK?

A. Sometimes, yes! Some OR people are a little bit like prima donnas and I have seen attempts to have them working in mixed teams which failed badly.

What is sometimes lacking is a sense of business and the reality of the business scene. We are inclined to spend a year building models and when we come back with the solution the problem has gone away, or the management has been moved or promoted. And there is this. It may be difficult to pursue a research activity in an operating environment, but we must resist going for more sophistication than the problem demands, or admit that we cannot help in the timescale required.

Q. I think we have got two things to think about, costs and benefits, and the former must be applied to the latter if we are to have any idea of whether the benefit is one we can afford. You have got to have at least some control and probably the most simple control is a money one; if you understand your rules you will know what you are doing with your numbers.

A. I agree with you it is useful to calculate numbers but it can be dangerous also. Figures get put into a summary report and sent to Head Office and the MD forgets his reasonableness for a moment, since he is a very busy man. He gets an accountant who looks through things and reports that the OR department 'lost' £70,000 last year and shouldn't it be shut down! It could be at a time of crisis, where there is not time to think about whether these numbers are sensible or not and they get used. On the financial point, I would argue very strongly that in production complexes financial data can be positively irrelevant and sometimes even misleading!

The Economic Aspects of Information

Professor J. Emery

If you will permit me, I would like to play the role of a professor—at least for a time—rather than as someone having some experience in the information systems business. The reason I want to talk about theory is that it provides an insight that can be very useful in a discussion of the economics of information. One of the things I want to show is that there are substantial theoretical problems in assessing the value and the cost of information, and it isn't too surprising that in practice we all are facing difficulties in trying to assess the relative merits of different computer-based systems.

BALANCING COST AND VALUE. THE ECONOMIC OBJECTIVE

The quality of information is a multi-dimensional characteristic since it has to comprise such things as the level of detail available, the accuracy, the reliability of the system, the response time, the timeliness of the information and so forth. As the quality of information goes up, quite naturally the cost builds up. Over a certain range of cost there may be certain economies of scale exhibited, but eventually as the information becomes of higher and higher quality, as regards one or more of its characteristics, the costs can start to go up disproportionately. This is a very well known phenomenon and each characteristic will show a different relation with cost.

In the systems we are currently designing, we are probably in the range where there are still substantial economies of scale—but this is not necessarily always going to be the case. The problem of determining the cost is of course a severe one from a practical standpoint, but there is no conceptual new problem in determining the cost of a computer system as opposed to other systems. The main difficulty arises from the fact that information systems, probably more than in most situations, exhibit some very significant joint costs and have typically a very large development cost component. The costing of a specific system then becomes much more difficult, and in theory one cannot assign to each individual activity a unique cost.

The actual determination of a value versus cost curve poses some formidable conceptual problems. In fact, it is the value of information that really represents the conceptual difficulty. Information does not have value *per se* but only in the way it is used, so that to assess the value of information one has to see how it is used and see what is the effect on whatever 'pay-off' measure one is using.

Let us look at the effect of technological change on the design of an information system. Suppose the technology before a change is represented by manual methods and we try to determine a quality level of information where its value minus cost (or net value) is maximized, as indicated at A in Fig. 1. Now, let us see what happens when the technology changes; presumably it is for the better—except possibly with the third generation of computers! The cost curve shifts so that for any given amount of expenditure one can get a higher quality of information or inversely for a given quality of information one can get it at a lower cost. That is what we mean by advance in information technology. The optimal point which maximizes the net value shifts on the curve as indicated at B in Fig. 1 and we expect at any rate to get information that was not economically available to us before—we get more detail, we get more timely information and so forth.

One of the problems that all companies face is moving from a manual system to the system that exploits the correct range of technology; all systems tend to be design-based on at least the previous generation technology. It is not unusual to find, for example, situations where a manual system was converted to punched cards in the early days and when the first-generation computer system came along, there was another straight translation; again the same with the second-generation and so on. There are many more cases of this sort of thing, in fact, than there are cases where organisations really think through as to how they can best exploit the current technology.

Let us now consider the case where the value of information does not change, but only the cost. Where can this arise? Suppose we take an information system using manual methods which is more or less at the optimal net value point. As the technology changes, and we shift to a new point, one alternative would be not to redesign the system but simply to exploit the advanced technology to yield a lower cost. When we have simply a cost replacement situation, then the classical investment techniques apply perfectly; that is if we are not changing the information content available to the manager—the response time, the accuracy and all the other things that presumably follow the advanced technology. Where we face the real difficulty is the situation where the value changes.

Under some circumstances it may be possible to assess the value of information, but in relatively limited cases. Suppose a new order entry system is developed so that the time lag from customer order presentation to the sales department until the order information is handled—the shipping papers prepared and all the information processing has taken place—is reduced from three days to one hour. Suppose, also, that rather than despatch the order to the customer in a shorter time, we use the saving in information processing time to allow meeting the original delivery turnaround by supplying from a central depot rather than from the original set of distributed depots. In this case, the output of the organisation, as it is perceived by the customer, may be identical; and one can do a relatively straightforward analysis to see precisely what the effects on physical distribution costs are by an allowable longer physical delivery time which is gained as a result of doing a faster information processing time.

If the organisation responds to a change in information processing in a way that makes the outside world look at the organisation in the same way as it did before, then one can do some value assessment.

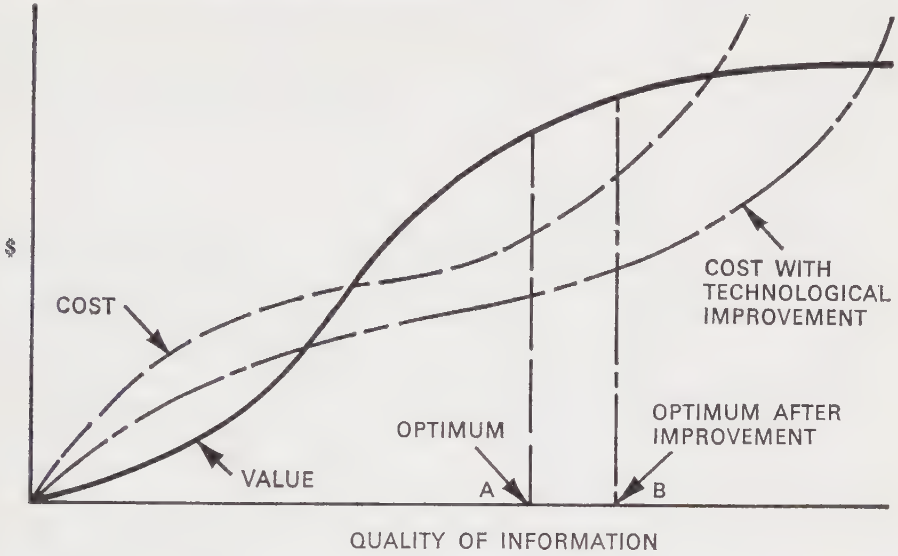

Figure 1.

Another example might be the case of an inventory control system that did a better job of controlling inventory in the sense that for a given investment in system facilities it could provide a lower probability of 'stock out', and, conversely, for a given probability of stock out it could provide this at a lower investment. Suppose that, with the installation of such a system, the organisation chooses to take all of the gains through a lower inventory investment maintaining precisely the same probability of stock out—here again the problem of assessing the value of the better inventory control system is relatively straightforward because to the outside world the system works exactly the same. Therefore, a value can be attached to the information.

In most situations, when information processing methods change, the behaviour of the organisation to the outside does in fact change, so that one inevitably has to get into questions of just what is better service worth, for example? Or what is better information provided to managers worth? And this is where the real conceptual problem arises.

In order to evaluate information we may find ourselves asking for a lot more supporting facts to go with that information. Let me take a very simple case. Probabilistic data is likely to be more appropriate than deterministic data in any theoretical treatment of information value. The point is, we can go to great lengths in extending an information model and making it more realistic, increasing the number of states of nature that we will consider—increasing the number of alternative actions, taking into account the probabilistic nature of the problem, taking into account the probability of errors in the information we get, and so on. The point I want to make here is that in order to assess the value of information using a simple model, as in the real world, one has to have a great deal of information. Let us just see what the information requirements are.

REQUIREMENTS FOR INFORMATION TO HAVE VALUE

We can break down a value assessment of information into a three-step process. First, it has to have a 'surprise' content in the sense that it has to tell you something that you did not already know; secondly, in the face of new information that has some surprise to you, you have to take an action that you would not have taken otherwise; and, thirdly, the action that your new information leads to has to provide a higher pay-off than you would have got otherwise. When we talk about information having surprise content, and the new information leading to a different decision, one always has to consider its incidence probability. When you design an information system you certainly do not expect every monthly or weekly report, or every transaction that comes in, to contain some wild surprises! You would be content if, relatively rarely perhaps, your market research information system, for example, gave you some information that was really actionable and told you something that you would not have known otherwise. Again, when we look at decisions, we do not expect every report to lead to a change. It is only over the course of time, that is to say it is only on a probabilistic basis, that we can say information has to lead to a change in action (at least sometimes) in order to have value. In some circumstances we may be willing to design very expensive information systems, even though the probability of getting a message of high potential value is quite low. If you look at some of the defence systems, for example, this is precisely the situation. The system that monitors the north pole area for missiles is a case in point. This system probably cost a couple of billion dollars to build, and I don't know how much to operate each year, but it really is a very simple information system with only binary information:—yes, you are being attacked; or no, you are not being attacked! The probability of the former message is very low—at least we hope it is—and yet, presumably, the value of getting that very message is sufficiently great to justify the system cost.

VALUE MEASUREMENT

Let us see now, in the real world, the extent to which we can actually quantify each of the three steps already mentioned.

In order to measure the surprise content you need to know formally what you know now (that is what your information system provides now), and you need to know formally what it will provide when you develop the system. In a forecasting system, for example, you would have to know things like the probability of forecasting errors now, and you have to know the probability of forecasting errors when the new system is available to you so that you can do a comparison between the two. In many cases, you may not know formally what your current system is providing or what the new system will provide.

In order further to assess the value of information one has to know how the new information will lead to a change in decision. You cannot really do this unless the decision process is highly formalised and, although it is certainly true that decision processes are becoming more so all the time, we are a long way from complete formalisation of decision models, particularly at the more strategic level of management. It is only at relatively tactical operational levels that we have a degree of formalisation that will allow us formally to assess the effect on decisions of a change of information input.

In the final analysis, if one wants to come up with a single measure of the value in monetary terms, one has to have a utility function or objective function expressed in the same terms. Again, in situations where we have this degree of formalisation, or it is a goal, we tend to be at relatively low levels in the organisation. At higher levels we might talk about 'profit' maximization as being our goal, but one simply cannot measure profit except by using accounting conventions, but we also pay attention to other measures as well, such as share of market, change in share of market, expenditure for advertising, R and D, which are really ways of guarding against too much attention to the imperfect measures of 'profit' which we have. The point is that rarely does one have in an organisation at the higher decision levels a well-formalized objective function which could be used in assessing the relative well-being of the organisation given two different information inputs.

SITUATIONS PERMITTING EVALUATION OF INFORMATION

As I mentioned earlier there is increasing formalization in decision processing, particularly in the logistics area; and that is why your initial studies in the inventory control area certainly makes a great deal of sense. Where such formalization exists, it may not be possible to attach value to an information system; but once you perform sensitivity analysis then it at least puts a boundary estimate on the value of information and that is a very important, if not the most important, part of most operational research studies.

I shall take a very simple example of an economic model, to demonstrate what I mean by sensitivity analysis. It is simply a formula that says that the economic order quantity (EOQ) for a given item is equal to the overall square root of twice the forecasted annual usage (F) times the re-order cost (R) over the inventory carrying cost (I). Fig. 2 shows that a 50% error in forecast results in only a 22% error in the order decision, because the square root relationship dampens the error. But what we are concerned with in assessing the sensitivity of this model is not the sensitivity of the decision itself, but the sensitivity of the 'pay-off', in this case the annual inventory cost, which includes carrying and order costs. Because of the shallow total cost curve, a moderate error in the re-order decision results in a very small error in the annual inventory cost. So that with a 50% error in forecast, leading to a 22% error in the order decision, we have perhaps only a 2% error in the pay-off in the annual inventory cost. There are certainly cases where pay-off may be quite sensitive to errors in input data, but the typical situation is that there is a considerable insensitivity. This is a very good thing because we live in a very imperfect information world!

The real point I want to make is that with the very simple model described, one could ask the question as to the benefit of having an absolutely perfect forecast instead of a likely 50% error and get the answer that the best we could do by moving from the present system to a perfect system would be a 2% saving in annual inventory cost. This may or may not rule the system out—there are a lot of cases where a 2% saving would pay for a great deal of information processing. Let us say that a 2% saving would justify the system, which would at least indicate that it is worth looking into things in more detail. You could start doing a more detailed analysis of your current forecasting system, e.g. not just get the maximum error but get a spread of errors, and by that means one could assess—'home-in' as it were—on the potential saving one could get from a better forecast.

With a formal model that allows sensitivity studies one can go quite a long way in assessing at least upper and lower limits on the value of information. Most operations researchers will testify that sensitivity studies are often the most important aspect of an operations research exercise.

Suppose we are facing the most common situation where we do not have the degree of formalization in our decision process that allows us to form sensitivity studies. What can we do under these circumstances? I think then we are going to have to rely on the judgement of experienced managers, but, in relying on their judgement, there are certain qualitative characteristics that we can talk to them about and get better estimates on their part of the value of the information and relate it to costs. These characteristics have already been mentioned and I now want to deal with them more fully.

INFORMATION CHARACTERISTICS

Let us first look at the detail and volume of data available within the information system. Certainly as one increases the volume of data being collected, being stored away, and being made available in a retrievable form, the costs

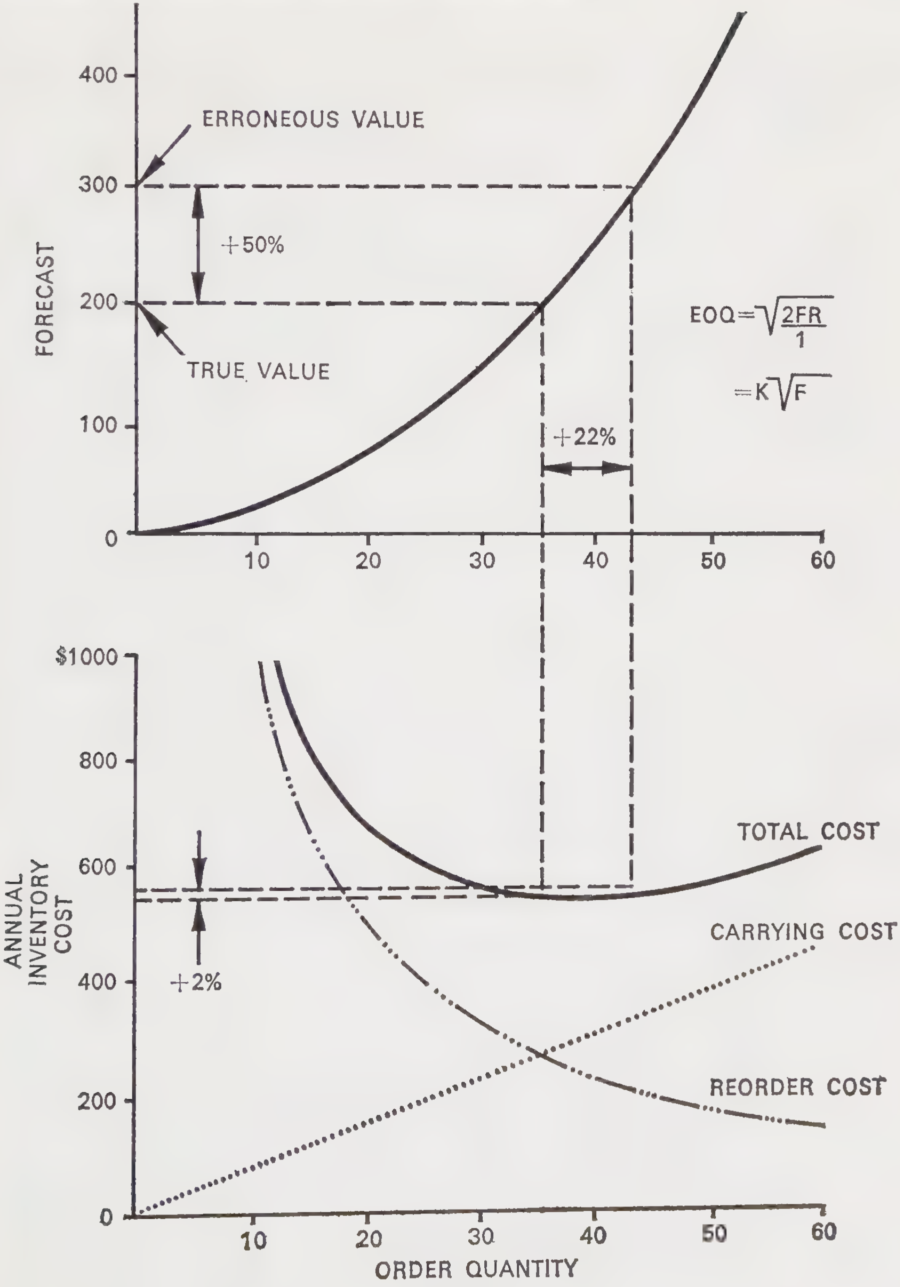
400
300
200
100
0
FORECAST
ERRONEOUS VALUE
TRUE VALUE
+50%
+22%
EOQ=$\sqrt{\frac{2FR}{1}}$
=K$\sqrt{F}$
10
20
30
40
50
60
$1000
800
600
400
200
0
ANNUAL INVENTORY COST
+2%
TOTAL COST
CARRYING COST
REORDER COST
ORDER QUANTITY

Figure 2.

go up. And let us look at the value of information—what is the value of having a more detailed data base available to a given manager? Using a simple example, suppose we are dealing with retail products (a supermarket, say). Suppose with earlier technology we can deal only with a limited data base and may, for example, only have a sales history by product group and by major organisational groupings consisting of a number of individual stores. With a newer technology, we may now have the means of storing more detailed information economically. We may have our sales history by individual product or individual store and perhaps by day of the week, if indeed the latter is a relevant decision variable in terms of stocking, distribution and so on. What have we gained by this? It means that with more detailed information available one can tailor the information inputs more precisely into the decision being made. You must consider the sort of decisions that you would want sales history data for; for example, you could want it for things like stocking decisions—whether or not a given item should be stocked in a given pack size in a given store.

In a particular USA supermarket chain, an earlier system had only division-wide item movement data. They had for a given division of the firm (say 200 stores) only the total movement of a given product for the last year; and, with that sort of information, were forced to make stocking decisions based on average movement per store. As a result, certain errors were made—for example, a decision was made on whether or not to stock 100 lb. sacks of flour. In analysing the movement, it turned out not surprisingly that not many 100 lb. sacks were sold, so—on the old information system having access only to total movement of 100 lb. sacks throughout the whole division—they made a decision that they would not stock this pack size. It turned out on closer inspection (going back into some detailed records) that 100 lb. sacks of flour were in fact sold by 2-3% of the stores—in rural areas where women still bake their own bread and insisted on such large sacks. The store managers rightly insisted that they had to stock the 100 lb sacks or they would simply lose the business. The point is that in the absence of detailed information you have no choice but to make decisions based on averages. But averages—as well we all know—can lead to gross errors, and when one has a more detailed data base one has a means of retrieving more facts and handling them in a way according to how the decision has to be made. So as we move from a highly-aggregated data base available to the decision maker to a more refined data base, decisions can be more tailored to the specific facts that have bearing on it.

Now the problem that many organisations are faced with, when they move to a technology that allows very large data bases, is to misuse it by feeling that as long as the information exists in the data base, somehow it is cheating the user if we do not display it to them—a very bad misconception about how information systems should run! The better the information system, in a sense the less the output from the system, since one wants the system to provide a filter so that only information having a high degree of relevance will be displayed.

It becomes all the more crucial as we start to expand the size of the base. One way of achieving selectivity is through the use of *ad hoc* enquiries. The idea is not to display information in a periodic report indiscriminately, but to respond to specific requests for information from various users and thereby filter what the user will not need.

In an organisation where the cost of selection is borne by the organisation—not necessarily by the DP Manager—it does not show up on his budget so typically he is biased in many cases towards publishing periodic reports of large volume, so that the users do their own selection. In any sort of reasonable systems analysis one includes the cost of selection along with the cost of providing the information; in many cases the overall benefits are very much greater if you spend more money in providing *ad hoc* enquiry services.

Another way of increasing the selectivity of the output of the system is through exception reports—standing enquiries, if you like! We simply establish the criteria of a standing nature that must be met, and only if the information falls outside acceptable limits is it displayed.

In producing routine information from an information system we sometimes forget graphical possibilities. It is now becoming relatively economically feasible to generate graphical output directly from computers, and a conventional printer can be a very valuable way of displaying information if one does not require high resolution.

Another characteristic that is always alluded to when one talks about the value and cost of information is that of response time. I am always very suspicious when DP people say that their system will give us very much more timely information and I think a lot of nonsense has been written about this. On the other hand, I am also suspicious of those who say that in virtually no circumstance is timely information—from say a real-time system—of any value to top management: I think both views are wrong for the following reasons.

It is useful to consider two aspects; one is the update response time—the time from event occurrence of an event until event information is found in the file; the other is the request response time. In many cases the technology is such that if you have on-line enquiry you can also have on-line updating; but it may make sense, for example, to have the former only.

Let us look at each one of these aspects separately. Under what circumstances will very rapid updating of the data base be of value to us? An airline reservation system, for example, demands a fairly recent picture of the current seat inventory. Lack of topicality could result in the need to maintain a safety stock of seats, so that you do not get full utilisation, the alternative being to pay for overselling in terms of customer ill-will and perhaps governmental action.

In inventory control situations—depending on such things as product sales environment—a high degree of topicality may be justified in the file, and on-line update could be of significance.

If you are at a higher level of management (above the operating level) on-line information does not make much sense at all. If you are making a decision about an annual operating budget or looking at long-range issues like basic R and D expenditure or plant expansion, recent information is of absolutely no consequence, as it does not really extend in any significant way the accuracy of prediction over the horizon that is relevant for long range decisions. So then, if we do not need recent information is there any reason to have quick response to enquiries? I think these are separate issues, and I can think of perfectly well-conceived cases where a manager can be perfectly content with relatively old information but he wants that old information very rapidly. Suppose he is making a decision on capital budgets for the following year. He certainly would not need recent sales data in order to do an adequate job, but on the other hand he may well want to get a quick response to questions like, 'What were my sales of this line of products in this territory'?

The key here is that the manager uses the information in an interactive way—in a probing manner—asking questions in a trial and error decision process. My own conviction is that technology is going to play a very large part in even high levels of management with this time of man-machine interaction. Paradoxically, as we move from lower levels of operating management to higher-level management the need for recent information decreases, but at the same time I think a very strong case can be made for saying that the need for interactive capability may actually increase. We must not forget costs in the response time context, and these can show considerable increases in moving from a larger processing system with say weekly up-dates to an on-line system with response time of the order of a few seconds.

Another system characteristic that governs value and cost is certainly accuracy. I suspect that in many cases there is an undue bias towards higher accuracy when perhaps it is not really necessary, particularly in certain accounting types of system.

Looking next at reliability, it can carry very substantial penalties in terms of cost—full duplexing, for example! The value of a reliable system is in the saving of penalties when the system goes down, and in one of the Westinghouse systems, for example, it was felt that a duplex system simply was not justified given the cost. They were willing to bear periodic breakdowns of the system and provide 'fall-back' procedures. They paid considerable attention to getting a single hardware system that was inherently a reliable one—it happened to be a Univac 490 designed for real-time application with relatively conservative electronic design and with attention paid to reliability.

Finally, what about flexibility? I think, quite rightly, information systems are condemned by managers for being inflexible, but I think that that is a characteristic of bad design rather than an inevitable part of the technology—or at least I would like to think it so. Even in a case where a change was not anticipated, and provided for specifically in the design of the system, there are certain things that we can do to make re-design a very much less painful experience that we often have. The obvious and typically neglected step of documenting the current system is a case in point, and though it may easily add 15–20% to the cost of implementing the system, it is a cost that simply must be borne. Also, we ought to design systems in much more modular fashion than we do at the moment. In too many cases, systems are simply too highly integrated in the sense that everything is one big 'lump', and a change in one part causes all sorts of ramifications throughout the rest. There is a cost to flexibility in terms of perhaps lowering machine utilisation, and the project manager must 'ride hard' over his programmers to see that they do not try to build in too many clever techniques that are too inflexible.

THE USER'S ROLE IN ACHIEVING A BALANCE

Let me close with a comment on how one can operationally achieve a balance between the value and the cost of information, the objective in any design efforts. The problem is that the information necessary to strike a balance between the value and cost of information is not known by any one group of people, but by different groups of people. The users are the ones that are able to assess the value of information because information only acquires value through use and therefore it is only they that can make the assessment. On the other hand, the users typically have a very imperfect idea of the cost of information. So a dialogue has to take place between the technicians and the users, and it might go something like this. The users probably have some notion of what information they want, and suppose they say they would like it with a response time of ten seconds. The technicians then say, perhaps, that to get a 24-hour response time to the same request for information could save £50,000 a year. The user now has some 'trade-off' information, and he may now say that 24 hours is totally unacceptable, but could you save me £20,000 by giving me a one hour response. You may go through a number of iterations of this sort, but that is the kind of process that is necessary.

The problem when we get into integrated systems is that it is not clear what the cost is, and it is certainly not clear who ought to bear that cost. If, say, we develop a data management system that provides an on-line enquiry capability serving all management, who is going to bear the cost? It may well be that for any one user the value is only £5,000 a year, but in total the value to the organisation may well justify implementing the system. The mechanics for doing that is by no means simple and I will end leaving that issue with you.

Q. You mentioned that fast response was valid for senior management. Surely, though, this pre-supposes that there is something between the

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data base and the manager. You are not saying presumably that this is only access straight to raw information?

A. You are correct. Having a quick response time relies on having the information system do a great deal of filtering, and the best filtering is through a model acting effectively as a very sophisticated filter. In the perfect case it filters out everything except the decision, but in most cases you do not want this because you want other things like sensitivity data. There is no question that if the information system is to serve high level managers in this interactive way there will have to be a great deal of filtering, if only to do the aggregating of data. If you do not know enough to model the process, then at least you will have to go through aggregation or data reduction.

An important consideration to which I do not have any real answer is this. Suppose you develop an on-line enquiry system and suppose for operational reasons you are also having on-line update. Problems could stem from having high level managers with very quick access to information at operational level, whereas operating management has not yet had a chance even to realise what is going on, let alone to correct the situation. There is a real behavioural problem in that sort of situation that I think we are going to have to face up to. One USA company is at least toying with the idea of not allowing high level managers access to data of less than 24 hour post-event life. I do not know whether this is the solution but at least they are trying it.

Q. I would like to challenge you on one point in which you sounded very much like a computer salesman. You said that it was easier to amend a computer system than a manual system, and my experience is the extreme opposite of this. With a manual system, it just means getting agreement from the areas concerned and changing the standard practice and perhaps issuing a new form. With a computer system it means amending programs which can be very expensive and takes a long time to do. My company does documentation very thoroughly, and in our inventory control system, many of the changes to the system are as a result of management becoming interested after initial implementation.

A. I was serious when I said that computer systems can be flexible, but I am perfectly willing to admit that some actual systems are not so. Let me give you an example of the sort of flexibility I mean, by supposing we want to add a new field of information to an inventory record. In a conventional system, this may cause all sorts of havoc and may require substantial re-programming, but with current technology using a suitable report generator or file generator it becomes a trivial change in a group header card which defines the records that you are augmenting.

The Economic Aspects of Behaviour and Social Change

Dr. B. Scheepmaker

CONTINUING AND IMPORTANT ROLES FOR PEOPLE

The interaction between a formal organisation structure and the individual, or personnel group, is clearly a very relevant issue for both the internal and external effectiveness of that organisation. Working 'to the rules' may provide a tidy and predictable bureaucratic system, and it can be argued that increasing 'system' formalisation (made more possible by mechanisation) is a desirable end. Nevertheless, the creativity of the individual or group contribution must surely continue to be of value; and particularly so in an external environment maintained dynamic in the foreseeable future by technological, and hence potential social changes. In fact, we are recently seeing more emphasis on system flexibility—and expecting it of technological aids—notably in the area of information for management. No substitute for 'adaptive man' seems likely at the moment, but the field of man-machine interaction must present one of the major system organisational issues of the years ahead and may radically affect economic value judgements.

A recent McKinsey report indicates an approximate two to one ratio for personnel and hardware costs in overall computer systems development and operating. No shorter term predictions seem to suggest any significant change in this ratio. The same report makes distinctions between technical and economic evaluations, and indicates that a subjective 'user' judgement may be comparable in weighting to an objective economic rating of a system. This is borne out, certainly, by the current high costs of system maintenance in relation to new development, and highlights the need for user management participation and benefit quantification in their terms.

A look at technology predictions in the computer field shows some interesting points. It would seem that punched cards—and hence a measure of human involvement in data derivation—are likely to carry on into the 1990s, and certainly many lines of advance are in the direction of man-machine partnership rather than man's replacement by machine—certainly in the commercial DP sector.

BALANCE OF SOCIAL AND TECHNICAL FACTORS

Communication between the organisation and its environment and between groups and individuals within the organisation, has both technical and social factors. The quality of the former may be determinable by system design and much effort can be expended on improving formal procedures etc., without due consideration given say to personnel attitudes.

Even when the balance of technical and social factors is such as to give a stable system in its 'settled' state, the question of the degree of stability arises when a change is to be made. It seems from experience that, regardless of the quality of planning for a change to a 'higher' level of rationalisation, a falling-off below the original level is initially and widely found until social adjustments take place. An unstable situation can arise, and require remedial action not included in the original change-over plans before the new (and probably validly-predicted) stable state is reached. User involvement and influence in the system feasibility and planning stages must certainly be considered of high priority where the computer is involved, if resistance is to be minimised during implementation and thereafter. A corresponding overhead in timescales, training costs etc. may well result, and must be legislated for in evaluation at the earlier project phases.

SOME RELEVANT ASPECTS OF INDIVIDUAL AND GROUP BEHAVIOUR

The effective interaction of people requires that the individual can co-operate with others on a basis of trust by the general acceptance of certain goals, interests and attitudes. An individual will take a subjective perceptual view of a new situation resulting from attitudes built up from experience; and its objective content will depend on how much the situation appears to affect him and the extent to which the new situation is covered by experience. His behaviour may be highly resistant to change if attitudes are involved, and it is usually easier to cause groups rather than individuals to alter behaviour patterns.

A resolution of behaviour conflicts is often a necessary step in the forming of rational situation attitudes, and its mechanism deserves some study in the context of the change at issue if the outcome is to be in the direction of lowering resistance to the change. Some factors affecting the resolution issue are:—trust in change initiators, opportunity to appreciate problem complexity and consider alternatives, feeling of control of environment, participation, introduction to the problem, timescales and so on. Again, 'self-interest' resistance factors can arise from material, self-development or status needs. The psychological investment of the individual in his work or environment must not be forgotten—it can be particularly high in long-established senior management and is often evidenced by stubborn antipathy to innovations.

The group should play a major role, and the particularly good opportunities usually presented for them by the sorts of situations being considered here should not go unexploited, it being accepted that there may be a tangible cost penalty in democratic decision-making over a longer time cycle.

ORGANISATION AND MANAGEMENT ISSUES

Paradoxically, the more centralised an organisation is, the easier is planning for major change but often the worse the possible sociological results. The more autonomy, the more co-operation—provided the autonomy is not in jeopardy—but implementation may be significantly slowed by the need for wider agreement, if only on interface aspects. System development and commitment must never (again?) constrain organisational change, and policy on information automation should be such as to facilitate rather than hinder it. Senior management are understandably sceptical over this issue, as they are also with regard to system flexibility on other counts.

We may expect there to be more direct use of the computer as a management tool in spite of entrenched attitudes. Many senior people dislike being thought of as 'professionals', and see no need for acquiring say an understanding of the management sciences—experts can always be found for preparing facts based on 'scientific' methods. However, now that the interaction problem is largely solved, managers would be very quick to see the potential of the 'raw' tool and the time may come when they call the tune on systems requirements for their direct needs.

Middle and junior management roles, where some degree certainly of the functions can be formalised, are bound to be affected to some extent by automation and the career progression of senior people in the DP area is another cause for general concern. Personnel management have a particularly difficult task in designing management or general personnel development programmes in a climate of increasing information and other automation, and the roles of computer personnel are themselves likely to change markedly in the next decade. Re-training is likely to become a major aspect of business operations, since it seems that more flexibility in personnel deployment is a consequence of technological advance. Certainly, some interesting cost and benefit issues arise from this factor alone.

Q. The search seems to be on these days for people who are 'innovation proof'. Could you enlarge on this from the development and recruitment angles—leaving out the age factor—and say how one could try to select own staff for transfer to the computer area?

A. Selecting or recruiting people on their depth and/or width of growing potential—without knowing which ways you will want them to grow—is really a problem. The trouble about unused personnel capacity is that it tends to atrophy unless given a chance to develop. I think the best thing for the longer term is to recruit intelligent people from secondary school or university, and set out a deliberate educational programme designed to widen their horizons beyond company limits, the programme to be conducted with more specific training in perhaps several jobs. You will need to face the company loyalty problem, of course? What you need are young flexible minds alive to the implications of technical and social change!

Investment Decisions Relating to Computers

Mr. K. F. Lane

ECONOMIC THEORY

The basic foundation of economic theory is concerned simply with the supply and demand of money, and an investment decision is a decision to spend money. Money is a commodity like any other, and if a firm wants money it has to buy it at a certain rate of interest which we can call the 'cost of capital'. If you have ever had to try to determine what the cost of capital is, you will know that it is not quite as easy as it first seems.

Having acquired capital, the opportunities that are open to the company to invest the money are its investment possibilities and, in order to assess these, one has to calculate an implied value which you can then weigh against the cost of capital. This is where we arrive at investment criteria, such as a DCF calculation where the whole point is to arrive at a figure that can be balanced against the cost of capital. If we calculate a rate of return for a particular cash flow, and if this rate of return expressed as a percentage works out higher than your cost of capital, then there is an obvious case for making the investment; if it is less then you reject it.

In order to arrive at a rate of return for an investment you have to produce, at some stage, a cash flow. Having spelled out what the cash position is for the basic situation, you then take the investment proposal as an addition to this and work out a combined cash flow. The difference between these two—the incremental cash flow as a result of the investment decision—is the cash flow you wish to discount. In practice, of course, arriving at these cash flows can be difficult, and some of the difficulties have been illustrated in relation to computer investment decisions by the presence of intangibles. Intangibles are not unique to investment decisions—you have them in nearly every decision because the decision itself will normally not be independent of the rest of the activities of the organisation—so that quite apart from the particular things which are initiated as a result of the investment decision, you have to take account of any impact there is by the decision on the rest of the organisation.

In practice things do not just boil down to doing a discounted cash flow calculation on an investment and comparing it with the cost of capital, since we have to face the whole problem of risk. You cannot spell out in detail what the present position of the company is, or spell out uniquely the consequences of the investment and consequently arrive at a unique cash flow that can be discounted. If you could do so, running your business would be remarkably easy—certainly as far as investment decisions are concerned. There are examples of businesses that come fairly near to a desirable situation; for example, a building society borrows money from investors and then puts it out to people who are searching for money to buy houses.

This is an obvious borrowing investment situation which illustrates very clearly the concept underlying discounted cash flow calculations. The question of risk makes the whole thing look very different indeed because you find you have a whole spectrum of consequences from the investment. The spectrum can vary substantially according to whom you happen to be talking, and although you can go through the DCF kind of calculation you find at the end you are still far from clear about what kind of decision you should take. This is because the range of possibilities nearly always spans the critical cut-off point that you are looking at—the critical cut-off point being your cost per capita.

I do not know of a good theoretical treatment of this problem which is really much help to the manager who is trying to make up his mind one way or the other about the investment. The usual theoretical approach is to appeal to statistics in some way and derive, say, an average rate of return or an average consequence of the investment. This necessitates trying to attach probabilities to figures. However, averages are really of no assistance whatsoever to people who have limited investment opportunities. It can be fine for the building society dealing with numbers of people to whom statistics can be applied, but for a company making fairly large scale investments this kind of logic is no good at all.

The question of selection from alternatives is something we should look at, and a study of an investment decision is really incomplete unless the question of alternatives has been explored, and explored thoroughly. You could equally describe it as a question of optimisation, and the whole area may be one for operational research methods even in apparently quite simple cases.

In summary, the method of analysing investment opportunities is to endeavour to see them in incremental cash flow terms, so that we know the implications of the investment. In real money terms, year by year, we can then translate this to a rate of return. In other words, we can calculate for it a price which is equivalent to the percentage cost of capital, and from this see whether or not it represents a good investment, insofar as the return on it will be more than we have to pay for the money. We can go on from there to introduce the idea of risk which means trying to put probabilities on figures and on accounts, in order that we can calculate average returns. Finally, we have to be sure all the way through this process that we bear in mind the question of alternatives.

PRACTICAL CONSIDERATIONS

I want to bring out some points that influence people when they are making decisions. Right at the top of my list is *judgement from experience.* You can be quite cynical about this if you wish but it means a lot in practice. If the particular group or particular individual putting up a proposition comes up with a set of figures which is at variance with what your basic experience over past investments has been, then you are very worried about it. In a lot of cases the experience that leads to an intuitive judgement (or an intuitive feel for a situation) is very indirect, but it can come from an addition of a whole lot of different situations in the past which are not perhaps exactly similar but which have elements which add up to your thinking. If you are thinking of doing something and a man with experience in the particular field tells you it is wrong, then you should always go back and think about it.

The next thing to consider is the *quality of estimates*. You may be able to bring your judgement from experience to bear on the given estimates although you cannot bring it to bear on the total proposition. Again, there is the issue of *personal assessment*. Where investment proposals are being fired at you from all directions, there are certain directions from which you accept the case without bothering any more, because you know they come from responsible quarters. On the other hand, you may be dealing with people whom you know to be wild or are unknown to you. With the wild ones you look for some reason to turn the proposition down, and with the unknown ones you have to resort to calling them in. The latter course can be really critical for a proposition since it can give you a chance to weigh up the individual to see whether he looks competent, and the kind of man who will follow an idea through. A decision may be taken on the basis of this assessment rather than on the detailed questions.

The next thing I want to talk about is *management capability*. What actually happens to a project is a function of the amount of effort, determination and so on that is put into realising the thing in practice, whatever inherent quality it had in the first place. When you are asked to make a judgement or take a decision you will need to be concerned with your capability to translate it into practice, as much as with the academic evaluation. Subjective Risk Assessment is a consideration that cannot be ignored. The person who makes the decision has to exercise his own judgement in relation to the risk, and this means that he is going to have to take his own view on the really critical issues in the investment.

The last issue is *possible strategic implications*. There are occasions when the company has certain strategic objectives such as wanting to become the majority supplier in the market, or something of that kind, where you can see the proposition in the context of your strategic objective and the decision making is almost automatic.

COMPUTER INVESTMENT DECISIONS

Looking specifically at computer decisions, you do have to look at the cost of capital because such decisions are often subsidised in one way or another. It is possible to finance them in special ways which means that they have a special cost of capital associated with them; for example, if you get a grant of

40% towards your computer installation it helps with the capital side considerably. Computer investment proposals, though, seldom formalise down to a DCF calculation. Where a DCF calculation is done, it has been attached on the end as very much an afterthought, since the main body of the proposal does not fit with this type of analysis. The point was made earlier that one is dealing with such wide estimates in such an area of uncertainty that actually going to the detail of a formal DCF is really unnecessary; I would think this is absolutely right. One of the points about a DCF is that you are all right with specific criteria, but very often if you are evaluating a proposition which has got a fair element of uncertainty in it, you can use a much cruder analysis which will tell you all you need to know or can reasonably work on.

Many propositions you read include fairly generalised qualitative considerations—such as the aim is to produce much better information and produce it much earlier and so forth. I have nothing against a qualitative consideration and if you cannot measure it then put it in as such. I do, however, have a lot against woolly thinking, and very often qualitative paragraphs are simply a cover-up for woolly thinking—one knows in practice that the people concerned have not really given any thought as to whether the information will be better, whether it will be more timely—and, even if it is, whether is it worth anything to the organisation. In the area of risk and sensitivity studies I have never seen this brought out too much, although in a lot of computer investments the risk is in fact quite heavy. If you are going to be one of the first customers to buy a particular set of hardware, or try some software, then this is a very risky situation to be in, and this should be recognised and spelled out as such.

The question of comparison of alternatives must be included as part of the total system project evaluation exercise. It must also be included to my mind as part of the computer evaluation exercise, and this is one of the most serious omissions of all. If you are trying to justify a computer installation, the kind of presentation in which you compare the computer possibility against the present system—and show that this represents a reasonable investment—is not good enough. It is necessary to say that we have an existing system which we can try to improve in this way or that way or the other way. One of the things we might do is to consider a computer, and see how this compares as an investment over and above the next best thing that you might do down the line. On the practical side, we have to remember that these proposals go up to a management very likely inexperienced in the computer field, so that they have no 'feel' for things and cannot bring an intuitive reaction to bear. They can be influenced therefore by things like public opinion and fashion and so on.

The same thing can happen with the quality of estimates; but I think the situation is improving now. I think we are now getting to the stage where there is pretty general scepticism and people consider that they have a feel for it. A lot of computer estimates are coming under fire for much the same kind of reasons as estimates in relation to any other investment come under fire. Management may well know of installations, which their friends and acquaintances have been concerned with, and hence appreciate the need to be ruthless and sceptical. Personnel assessment is particularly relevant because of the new technology. People who have been involved with it are often low in experience in the company application area at issue, and it is not always possible for the decision-makers to look at a record of performance. They, therefore have to judge the people concerned on the basis of a half hour meeting in the board room, or something of that kind.

It seems to me we have had many computer propositions put up which have almost bordered on being dishonest. We have arrived at a stage where this country, and other countries as well, have invested vast sums of money in computer installations. This money, as far as one can judge, is on the whole not very well invested. One could hope that one would be proud of the history, but I am not sure this is the case.

Q. This business of alternatives is, of course, a very lengthy business. This comes back to the depth of study and the realism of the proposals. One finds oneself over and over again with quite insufficient time to study things in sufficient depth. In a company that I was associated with, we had to look at ten basic different ways of doing the job, plus eight different manufacturers in the computer alternative. What does one do about this?

A. You need not do them all simultaneously; in fact normally you cannot. You have to let the proposition evolve, I think! You may have to phase things in with the evolution of the organisation, and it could be that a conscious decision that a prior look at alternatives is premature must be made.

SECTION 3

Specialist Group Reports

The general discussions held on the first day of the Workshop resulted in three specialist groups being formed to cover Benefits, Costs and Behavioural Factors respectively. The groups were asked to consider their subjects in the context of the project work already done, and to comment on the proposals made for further study in the Inventory Management Working Party Report. The reports made by the Chairmen of the Specialist Groups on the last day of the Workshop are summarised below.

Benefits

Mr. J. D. Humphries

One of the first points that came out of our discussion was that we first considered whether we were talking about benefits in the situation of starting EDP for the first time, or devising a new system to be added to an existing computer-based set-up. We concluded that there was no significant difference for our purposes.

We used as a focal point the list of stimulating factors and benefits given in the Report, and largely agreed with its contents. We propose two significant additions to the list. First, there is the benefit of improved presentation of information—the ability to present perhaps the same information in a variety of different ways and in a way more easily acceptable and intelligible to the user. And secondly, there is the benefit of working towards systems integration within the company, with a resulting greater consistency in activity, standardisation and communication. The last can give significant benefit away from the computer field altogether, and should be actively looked for as a factor stemming from systems development in general.

At the outline level at which the check list is formulated, we agreed with the comments in the Report that it has general applicability and is not related particularly to inventory management application. It was thought, however, that one would in fact end up by adding a variety of sub-headings to it, and this development in greater detail would become progressively more application-dependent. This was not considered to be an insuperable problem.

The problem of putting 'weights' on the different benefits is something that is related to the particular application situation and the risks involved. One of the key things that came out of the discussion on how one values benefits was a strong feeling that, while one might put forward a variety of methods to help people, in the end the only thing that matters is the valuation a manager puts on the information to him.

When we started looking at the techniques which should assist people in putting values on benefits, we noted that there were circumstances in which people would decide that the easiest and cheapest way of putting an estimate on the value of a new system was actually to put that system in. In many cases there might be a conscious decision that benefits were going to come and that the company was prepared to risk so much money on it to find out. This undoubtedly happens unconsciously in many cases, and we suspect that it could still be considered to be a valid approach if done consciously.

It was felt that valuing benefits (and admittedly a lot of these comments equally well must apply to valuing costs) should be done with a level-by-level type approach, and that the first thing was to get a very rough estimate of what were the constraints. One can put a series of constraints on the problem which will clearly identify which are the things you really need to start examining in further detail, and which things you can dismiss as being either obviously proven or not worth following. This should be one of the first actions that should be done, a sort of 'Ball-park' estimate. It was also said that we needed, as part of our check list, a mention of the constraints that apply which can limit the extent to which one might achieve benefits.

Looking ahead as to further work which should be carried out, we considered that there was a definite need to get agreement on the conventions to be used in costing—the straight accountancy conventions to be adopted—and this was something that should be very high on the priority list. Initially, further work should concentrate on revising, developing and validating the check list; getting case study information; and also looking at relevant practices outside the computer field. It was pointed out that similar problems arise in other fields, and there was already quite a degree of established practice.

Concern was expressed about the extent of the support for further work, and it was felt that before very substantial resources were committed, it was necessary to test out the extent to which people were directly prepared to support it. There was considerable discussion about the validity of the questionnaire approach to obtaining information. The desire for getting the information was recognised, but there was a great deal of scepticism among some people on the practicability of the questionnaire approach on the scale that was being proposed. It was suggested that NCC should try to obtain this information as an incidental part of its activities with individual companies, i.e. as an incidental operation rather than mounting a specific exercise, though it could not be done as a half-hearted exercise. It was also suggested that the question of getting people to provide this sort of information should be linked in with the testing of future support.

There was a very definite belief in the importance of the modelling approach which had been suggested in the report, particularly as a research tool, and that this should go ahead. Note should be taken of any other relevant work on models going on in other fields.

Costs

Mr. C. M. Reddington

First we considered whether one can define the difference between the way in which costs are determined for evaluation purposes, and control purposes. We concluded that there should not be any difference, and that it was perhaps a wrong way of looking at the problem to try to make the distinction. If we are talking about the evaluation of a project and the subsequent control of it, unless we are in fact using the same basis of costing for both aspects, control does not mean anything.

We recognise the problem of control costing—to decide where to put the onus for determining whether things have been successful or not, whether in fact it met its objectives, whether it was worth doing—and there is perhaps a distinction between a costing mechanism and a charging mechanism. We came to the conclusion that it would be a preferable strategy to make a charge to the user for computer services which may include both operating and system development cost components. The user does not have to worry how it should be worked out, and he can measure his benefits against those costs to him—although of course he will have other costs in implementing the system beyond those charges passed over from the DP side. It refines and simplifies the problem to some extent, and leaves the DP side with the problem of conducting a commercial strategy. Obviously the mechanism by which they charge out is not unrelated to the basis on which costs are incurred, but it does not need to have the close correspondence that we were trying to seek in the first place.

We then recognised that within the DP area costs came in three different categories; first, pure capital for the hardware provision; secondly, the capitalised aspect of what would normally be considered revenue expenditure, in other words the cost of the developed system; and thirdly, the operating costs.

The next question is that of predicting costs. To what extent is it practicable to predict costs, how is this related to the appraisal—implementation—monitoring cycle, and what further tools of measurement are required to improve the accuracy of prediction? We agreed that things might have to be well advanced before costs can be predicted with any degree of confidence whatsoever. Until one can categorise or define modules which are to be used to make up the system, any cost estimate is something 'out of the air', unless one has some analogous situation for comparison.

On the question of whether it is desirable to attempt some measure of standardisation of the allocation of tangible costs, it was agreed that it would be certainly useful to have a check list; and that at least we should have some ranking of these, some degree of sensitivity analysis which would indicate, if not necessarily the orders of magnitude, at least some ranking aspect of the various factors for apportionment.

We agreed that one way of looking at predicted costs could be the relationships between the various parts of a project. In other words, if one cannot say that this is a system of complexity 'x' (or of so many units of output) which is going to cost so much, at least one might be able to say that the relationship between hardware, systems investigation and programming costs will be of this order of magnitude or relationship.

Behavioural Factors

Mr. A. Pearson

We considered the changes in morale which arise out of the introduction of computers, but we were not convinced how we should measure these factors. It came down in fact to a look at secondary variables in terms of labour turnover and so on. It came out quite clearly that those people who have got examples were back to the old case study problem—for every one you can quote I can quote an opposite! We also felt that the effects on morale and resistance to change would depend upon the type of organisation, and the stage which had been reached in introducing computer technology. We identified separate situations of using a computer bureau instead of installing one's own computer, putting a new computer in, and increasing existing machine capacity, and we felt that each of these had to be looked at independently.

The over-riding things that came out were the questions of the importance of key people, of selling the idea, and getting top management involved in the project from the very beginning. If we knew more about who these people were in the organisation, and what influence they had on the system, it would be far better and so we concentrated our attention on looking at what research work ought to be done in this area. We think that it would be useful to look at a small number of variables over a large range of companies, and that the important variable is these 'top people'. We suggest that one should go out and investigate twenty, thirty or even a hundred companies, and interview the people who are primarily concerned with the introduction from the very beginning. On estimates of the effort required, I suggested that somebody might do twelve of these in a year. The intention is that one would go back to the very beginning, when the feasibility study was being written up and when the negotiations with computer people were in fact going on, to try and identify who had been involved and what they said they were going to do. One would want to look at both successful and non-successful installations, since nobody had any real measure of success. So we are recommending that one ought to take a look at what seems to be the major behavioural variable, that is the influence of the key people in the system in the relative success or otherwise of the project.

We then went on to discuss secondary variables like labour turnover and management education and the only reason I call these behavioural variables is because they affect people. They are in some senses costable, and one could go out into a large variety of organisations and actually establish what the costs have been in situations in which the people have put in computers.

One of the factors that we debated was the question of how much involvement of other people in the organisation was required when one was installing a computer, that is other than the programmers and systems analysts who would come under direct costs. How many people did they get involved with, who did they go and talk to, how long did they spend with these people? This would involve top management, middle management, people on the shop floor, and unions. These are very real costs here, in the sense that one has to incur them, and there are some obvious repercussions on the benefit side. Is it feasible to measure these costs? We thought it was, by some method of either getting people to write down every contact they had with a systems analyst or a programmer or by doing some random sampling. We could relate this amount of time to the type of industry, the size of industry, and the type of system situation.

SECTION 4

Final Workshop Report

Dr. T. A. Duerden

I think we must try to see how far we have succeeded over the last 48 hours in reaching the objectives that we set ourselves at the outset.

You will recall that we saw this workshop as a way of guiding future activities, if any, in this field; and to that end, we had presented to us the work that has been done to-date within the project. We were also going to listen to the views of international experts in this field, and finally we were going to provide for a more general and informal exchange of views. There is no doubt in any of our minds, I am sure, that at least our subordinate objectives have been met. We have had very clear presentations of the work done to-date, we have all not only enjoyed but benefited from the formal lectures that have been given, and there has been no lack of discussion in the groups and informally afterwards.

It is—not surprisingly—less clear to see just where we go in the future, and the very volume and quality of the comments and contributions that have been made have ensured that there will be a data processing time involved before we can finalise the next stage. However, it seems to me likely that the proposals that have already been made by the Inventory Management Group will not need to be changed all that significantly as a result of the extra input that we have had throughout the workshop, which is a very significant comment on the quality of the work and experience these people have put in.

What bothers some of us is the rather disappointing support that there has been for the overall project concept. As Mr. Dorey indicated, the response to the current practice questionnaire was not uniformly high, and there is plenty of evidence that people in industry and business are buying computers at an accelerating rate, apparently quite relaxed about the whole situation. If we were not so keen on 'flogging ourselves to death' we would just be busy meeting the demands of our managers in providing the system, and not worrying too much about whether it was all economically justifiable. I find it difficult to go along quite with that view, and I am sure that sooner or later we have to get better at this evaluation business; but something that we have to bear in mind must be this rather negative attitude in deciding the course of our future activities.

In particular, I think it may well mean that future work ought to be properly balanced between producing short-term evidence of improvements that are possible, balanced against the longer term results of research. I think the worst thing that could happen would be if the programme of work that came out of this activity looked to the world at large as yet another academic exercise to support the learned institutions, and not to help industry. I think that would be very sad, and many of you have said that we should keep a balance; let us have some short-term output from the research that can be of value, whilst carrying on in the background with long or short-term fundamental studies. We have seen quite a lot of evidence that we are a long way from defining and resolving the problem in many important areas.

We have established a large number of contacts with users, and many of those who have answered the questionnaire said that they would be prepared to contribute to the future development of this study in the form of providing case material or facts or whatever. We shall certainly want to take advantage of that offer.

I would like to finish by thanking, on your behalf, all the people who have made this event possible. A special vote of thanks is due to Professor Mercer for organising the workshop and to all the speakers. It really is asking a lot for people to give up their valuable time to prepare and deliver a lecture, and then 'kick them about' and so on. We are very grateful to them for the way in which they have been willing to be exposed to considerable comment. The NCC now have you all on their mail-list as far as this project is concerned, and will no doubt be regularly feeding you progress reports about the 'state of play'. It may well be that we shall feel it appropriate to have another event of this kind at some significant milestone in the not too distant future.

SECTION 5

Attendance List

1. *Guest Speakers*

Dr. G. H. C. Ardron	Unilever Computer Services Ltd.	Managing Director
Professor J. C. Emery	University of Pennsylvania (USA)	Professor of Industry
Dr. P. J. Coen	Logica Ltd.	Manager, Management Services
Mr. C. J. Constable	Durham University	Assistant Director Business School
Mr. K. F. Lane	RTZ Consultants Ltd.	Managing Director
Dr. B. Scheepmaker	Institute of Applied Psychology (Holland)	Consultant

2. *Computer Users*

Mr. N. Boodson	Lightening Fasteners Ltd.	Merchandising Manager
Mr. K. J. Camp	Kodak Ltd.	Systems Group Head
Mr. H. F. Dammers	Shell Chemicals Ltd.	DP Manager
Mr. E. N. Evans	Phillips Industries Ltd.	Group Computer Co-ordinator
Mr. S. A. Evans	Electricity Council	Technical Officer
Mr. N. Forsyth	Nuclear Power Group	Head of Systems Analysis Group
Mr. W. M. M. Kerr	C.E.G.B.	Computer Operations Manager
Mr. M. N. Merritt	Allied Supplies Ltd.	DP Manager
Mr. P. L. Rule	Delta Metal Ltd.	Computer Project Manager

3. *Overseas*

Mr. A. Bagge-Peterson	Handelsbank, Denmark	Deputy General Manager
Mr. A. Bujoza	Institute of Informatics, Madrid	Director

4. *Professional Bodies, Government etc.*

Mr. C. T. Bocutt	Science Research Council	Senior Scientific Officer
Lt. Col. J. A. Burton	British Computer Society	Chairman, Business Management Group
Mr. G. B. Esselmont	Institute of Chartered Accountants of Scotland	City Chamberlain Corporation of Glasgow
Mr. A. R. W. Hill	Association of Certified and Corporate Accountants	Courses Officer
Mr. E. J. Howe	NCC Ltd.	Head of DP Group
Mr. J. D. Humphries	NCC Ltd.	Head of Corporate Planning

5. *Manufacturers and Consultants*

Mr. J. B. Aris	ICL	Manager, Applied Systems
Mr. R. L. Butler	W. S. Atkins and Partners	Chief Planner
Mr. J. Feeney	Hoskyns Systems Management	Manager, Data Centre
Mr. P. Healey	Scientific Control Systems	Analyst
Mr. W. Saunder	Urwick-Diebold	Consultant
Mr. G. E. Williams	Attwood-Auerbach Ltd.	Managing Director

6. *Universities and Business Schools*

Professor A. S. Douglas	London School of Economics	Professor of Computation
Mr. J. Eaton	London Graduate School of Business Studies	Lecturer

Mr. M. C. Bonney	Nottingham University	Lecturer
Mr. R. J. Haynes	Imperial College	Graduate Student
Mr. A. W. Pearson	Manchester Business School	Director, R & D Research Unit
Mr. R. Stamper	London School of Economics	Research Fellow

7. *Members of the Project Committees/Groups*

Dr. T. A. Duerden	British Aircraft Corporation	Chairman, Overall Project Committee
Professor A. Mercer	Lancaster University	Chairman, Workshop Committee
Mr. G. S. Dorey	Pfizer Ltd.	Chairman, Current Practices Group
Mr. F. F. Land	London School of Economics	Chairman, Inventory Management Group
Mr. O. B. Chedzoy	Bath University	Lecturer
Dr. J. Hawgood	Durham University	Director, Computer Unit
Lt. Col. W. E. M. Morris	Durham University	Project Officer
Mrs. E. Mumford	Manchester Business School	Senior Lecturer
Mr. C. M. Reddington	Liverpool Corporation	Assistant City Treasurer
Mr. G. I. Ryder	English China Clays Ltd.	DP Manager
Mr. G. S. N. Condrup	NCC Ltd.	Regional Officer
Mr. R. Boot	NCC Ltd.	Head of Methods Department

8. *Workshop Administration*

Mr. C. W. Blaxter	NCC Ltd.	Project Secretary, and Workshop Administrator
Miss V. Schofield	NCC Ltd.	Secretary
Mrs. J. Stefanuto	NCC Ltd.	Secretary

Books 1 and 3

A SUMMARY

In **Book 1** is detailed the Report of the Working Party's work during 1969 and early 1970. The object of the Report was to present the ideas and conclusions reached by the Working Party during their many meetings. Section 1 summarises the Report, detailing the brief from which the Working Party was set up, the various interlinked strands of research which were developed, and the tentative conclusions which were reached. In section 2, the Working Party examines the nature of costs as far as the project is concerned, trying to identify the costs which are relevant, and going through the process whereby firms can try to estimate the possible future costs involved in installing a new computer system. Section 2 concludes with a listing of cost variables, which are dealt with in more detail in the Appendix to this book, and an examination of the charging policy of an in-house computer operation. Section 3 comprises an examination of stimulating factors, and benefits which might result from the introduction of a new system. In section 4, two interlinked research methods are described, the first being the development of a computer model of an inventory control system, and the second the use of questionnaires, including one which has been designed to provide data for the model. Finally, an annotated bibliography appears at section 5.

In the **Appendix to Book 1** John Hawgood and Enid Mumford present the common approach to the project evolved by the Working Party through many days of discussion and argument between January 1969 and June 1970. The Working Party considers that this Appendix, which will be available separately printed if required, will be useful in itself to managers faced with problems of whether and how to introduce or change computer-based information and control systems. In section 1, elements of the strategy are listed and described, some of which are dealt with in more detail in the main part of Book 1 and in Book 3. In section 2, details of the strategy are analysed, under the headings: System planning—long term strategy; System planning—short term requirements; System implementation; and System operation. This section is an expansion of the listing of cost variables prepared in section 2 of the main part of this volume. In section 3, options and outcomes are discussed, and decision theory is applied to a simple problem connected with the feasibility study,

system design, and implementation of a possible information system. Finally, also in section 3, two possible situations are discussed in which decision strategy might be applied.

Book 3, "Systems Design for People", sets out the arguments for a more systematic consideration of the human factor when systems are being designed, and provides a simple method for thinking through technical and social variables. Section 1 attempts to define the problem, which is the need to design systems to take account of both social and technical requirements. Section 2 details the suggested method, consisting of three main stages—(1) the possibilities, needs, and constraints; (2) the merging of technical and social solutions; (3) establishing the viability of a particular socio-technical solution. Section 2 ends with an examination of points to be taken into account when considering technical and social needs. The method detailed in section 2 is then used in two studies, one, in section 3, in a Local Government situation, and one, in section 4, in an industrial situation. Finally in section 5, a method, entitled System Adjustment, is described of exploiting system possibilities as a way of avoiding social costs, and this section ends in a description of policies, strategies and resources required if it is desired to secure the possible advantages of a computerised work system.

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